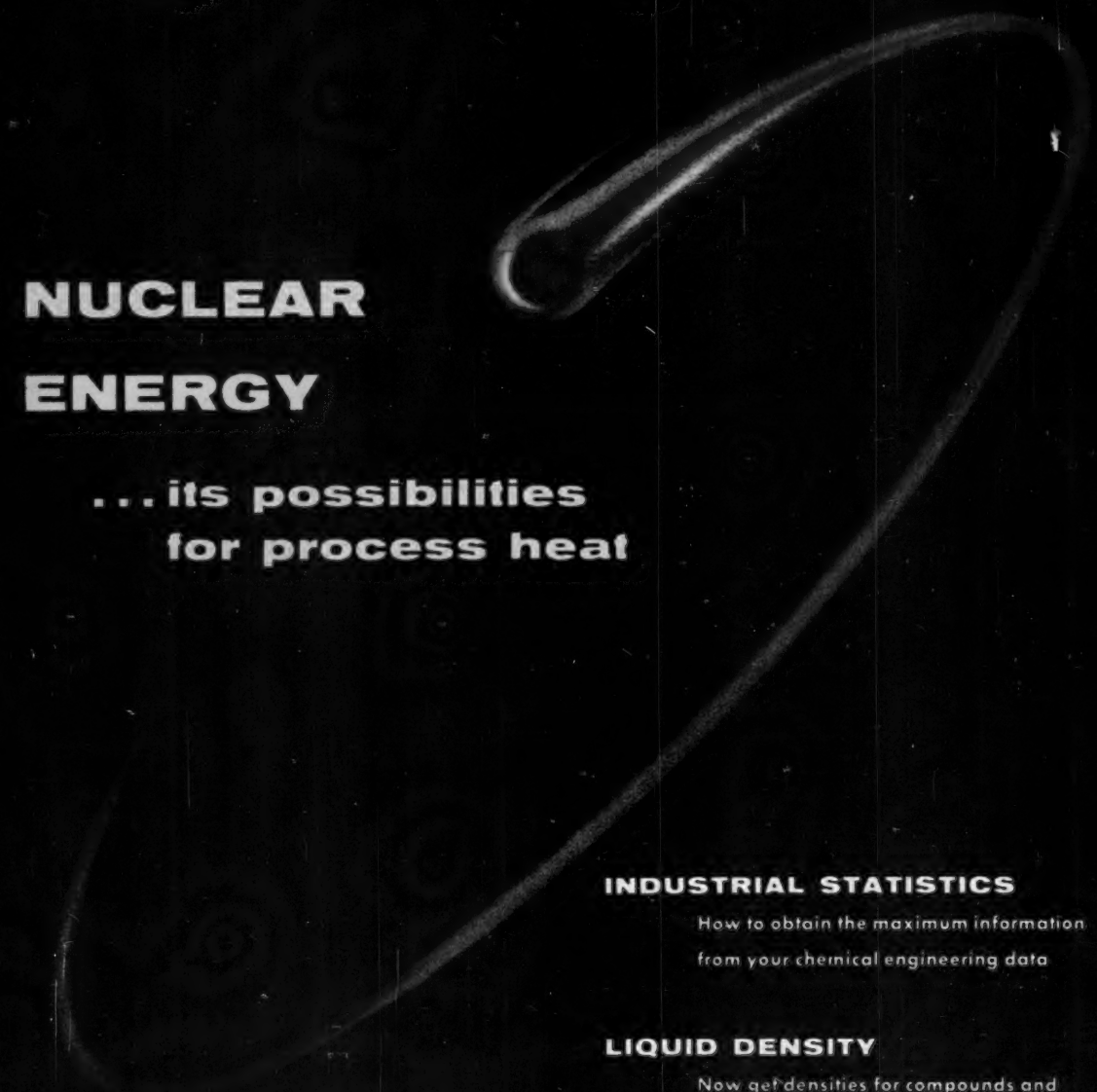
Chemical Engineering

MARCH 1956



NUCLEAR ENERGY

... its possibilities for process heat

INDUSTRIAL STATISTICS

How to obtain the maximum information from your chemical engineering data

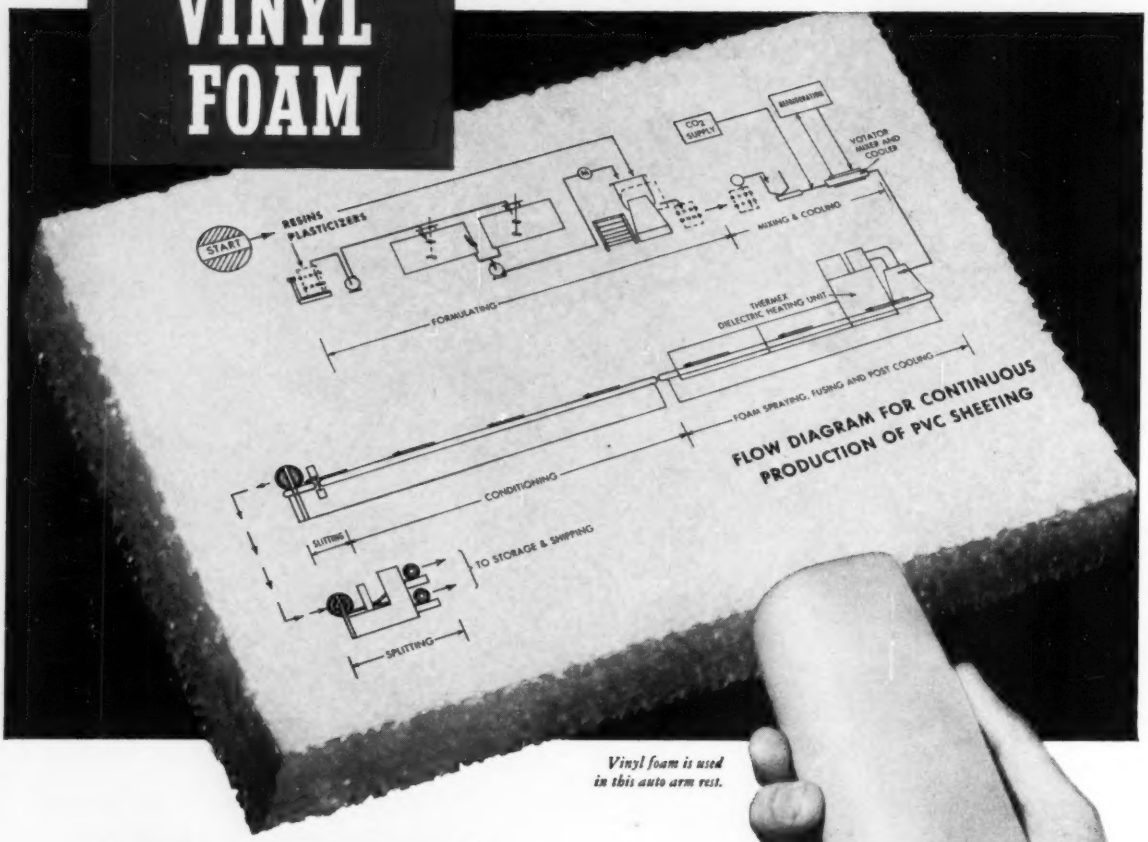
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ONE DOLLAR

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Vinyl foam is used in this auto arm rest.

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Vinyl foam, now out of the pilot plant and into mass production, is bringing important advantages to many products. Here is another great achievement of American industry in which engineers of Girdler's Votator and Thermex Divisions have made vital contributions.

The flow chart shows the basic elements of a system for the continuous production of polyvinyl chloride foam sheeting. This versatile system, in which the Elastomer Process† is widely and advantageously employed, makes possible the use of many resins and plasticizers for the manufacture of open-cell flexible vinyl foam in a broad range of resiliences. It is used for both flat stock and molded articles.

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March 1956

JOHN R. CALLAHAM, Editor

Easy Way to Save Time

Most engineers don't find it easy to prepare technical articles. They're prone to shy away from writing, to procrastinate or "sweat it out" the slow, hard way.

The typical engineer author often spends a third of his time assembling data, two-thirds "composing" the article.

That isn't necessary at all, for we can pass along tips that'll save 50% or more of your time.

First thing to remember is this: We're vastly more interested in the subject, treatment, slant and factual content than in the niceties of style. Nor are we fussy about mechanical aspects of the manuscript.

You don't even have to type the manuscript, though naturally we prefer it. We've published many manuscripts submitted to us in long-hand.

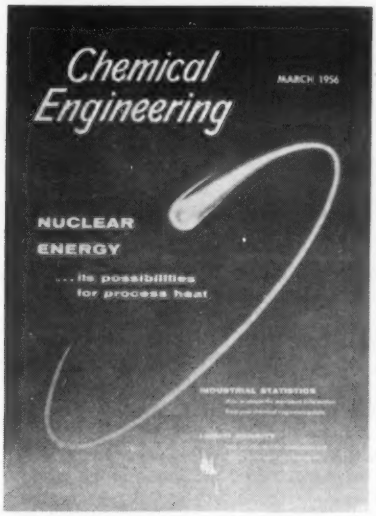
You don't have to spend a lot of time preparing inked drawings; our art people will redraw them for standard lettering anyway. Make them legible and easy to understand—freehand, pencil or ink . . . That's all we need.

You can see, then, how you can cut down non-productive time if you concentrate on contents, facts and accuracy and let our experienced engineer-editors handle the details of style, organization, finished drawings and the like.

If we have questions we'll get in touch with you. If we make major changes we'll ask for your approval.

If you'd rather handle details yourself and submit a "finished" manuscript, please remember: We —like most editors—reserve the right to make any changes that are necessary or desirable for style and organization as well as for conformance to space limitations.

For a quick decision on your article or story idea, for tips on how to get higher readership, for shortcuts that'll save you time and effort—get in touch with us before you start writing. JRC



GUIDED TOUR

Let's preview fission heat for chemical engineering operations

There's a good reason for all the excitement about fission heat—it's going to permit reactions that are not feasible now. Here we're previewing what you can expect to see —and probably use—within a few years to cut fuel costs and increase efficiencies of high-temperature operations. (p. 191)

New data, new designs, new wrinkles

To help you keep up with what's happening, we've five exciting ideas: special heat exchanger design, new heat transfer data, novel shaft seal, a kiln wrinkle, a continuous atomic power process. (p. 113)

You can use industrial statistics

It's a new science—all ready to help if you have to make decisions based on col-

Please turn page

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MARCH 1956

GUIDED TOUR

lected data. Our special 26-page report on the new dynamic procedures will guide you through the fundamentals. (p. 165)

Densities by the thousands

Alas! Only 368 compounds for which density data are available over a range of temperatures. If your design problem is not one of the 368, this new nomograph will extend the handbook data. (p. 196)

To put stilts on pipelines

How to design pipelines that are to be supported above ground. How to get the right structural strength. How to make them self draining. (p. 199)

How to organize for top performance

For new insight into the problem of setting up a group to do a specific task, take a look at this new workable method. It's good whether you're planning a small research task force or establishing a whole new company. (p. 218)

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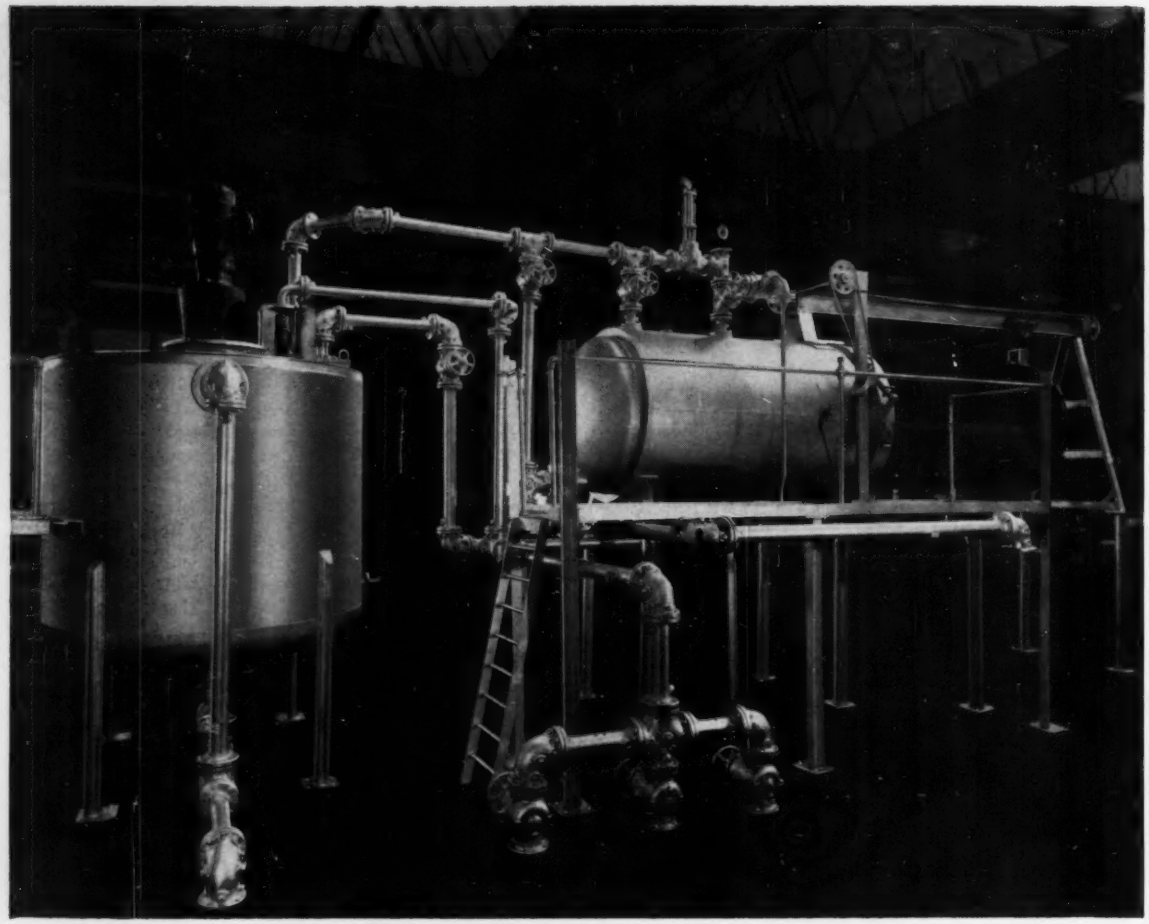
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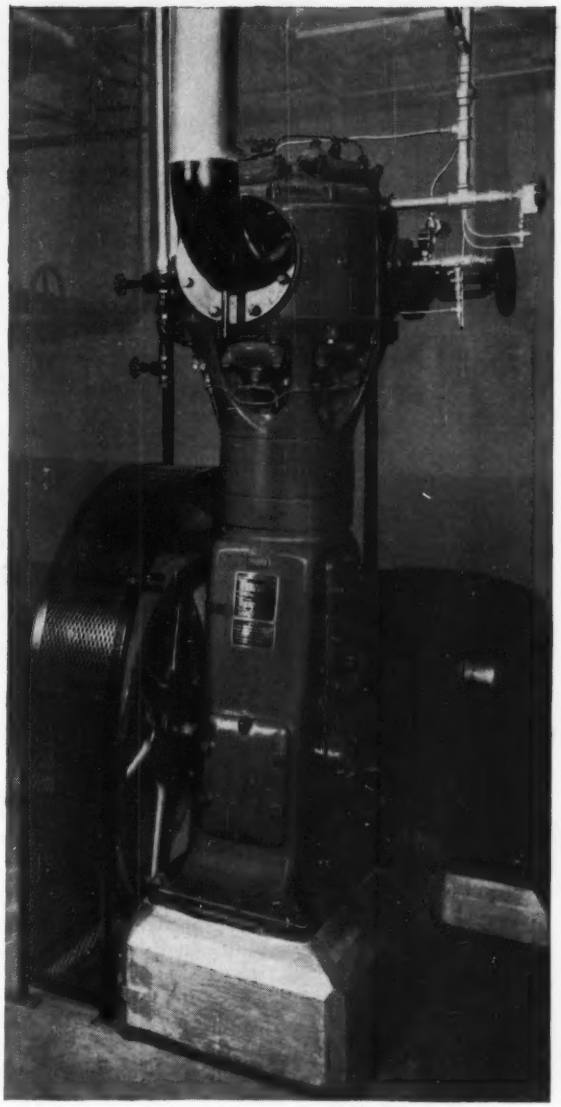
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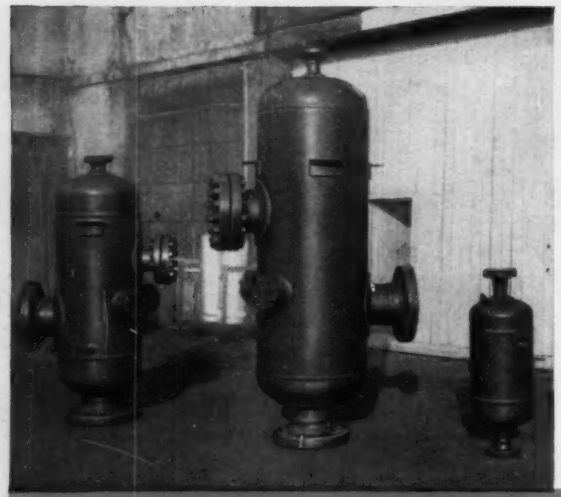
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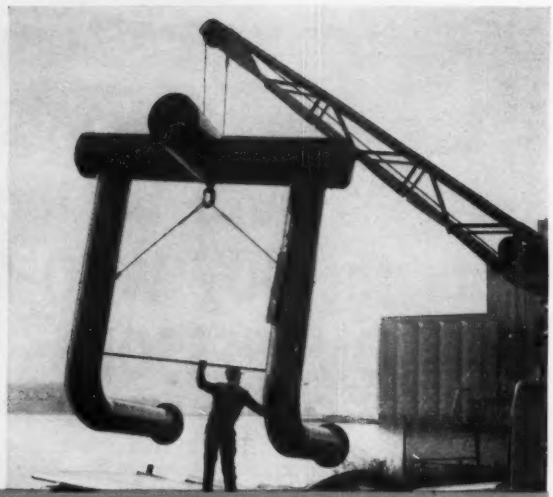


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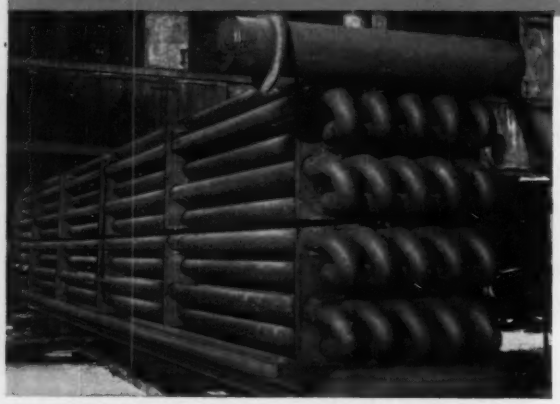
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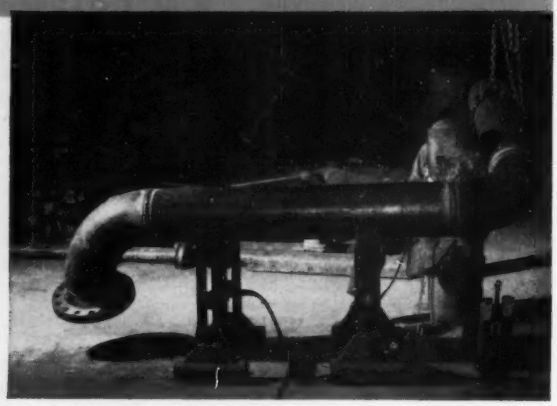
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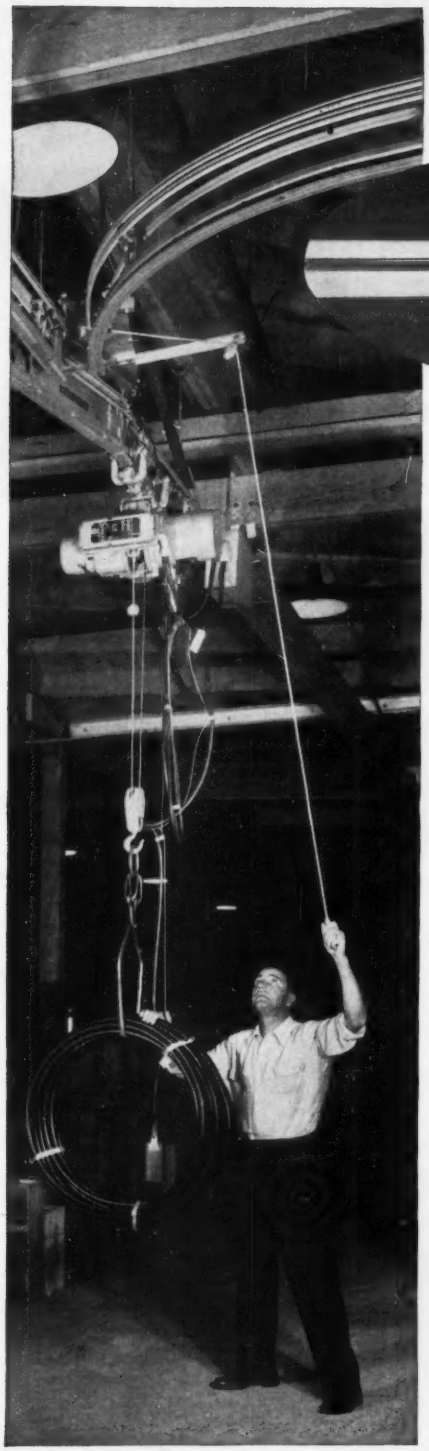
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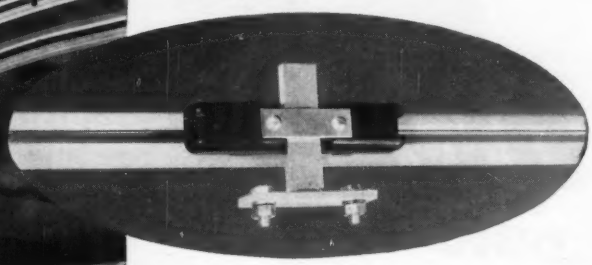
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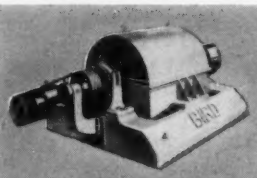
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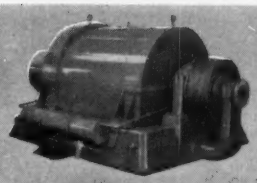
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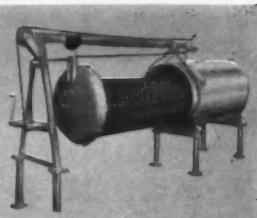
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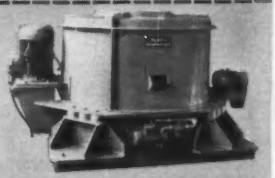


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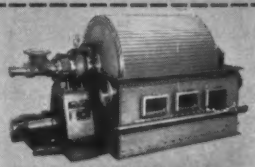
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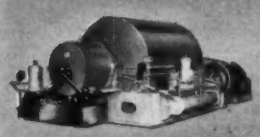
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FARVAL—
Studies in Centralized Lubrication
No. 169

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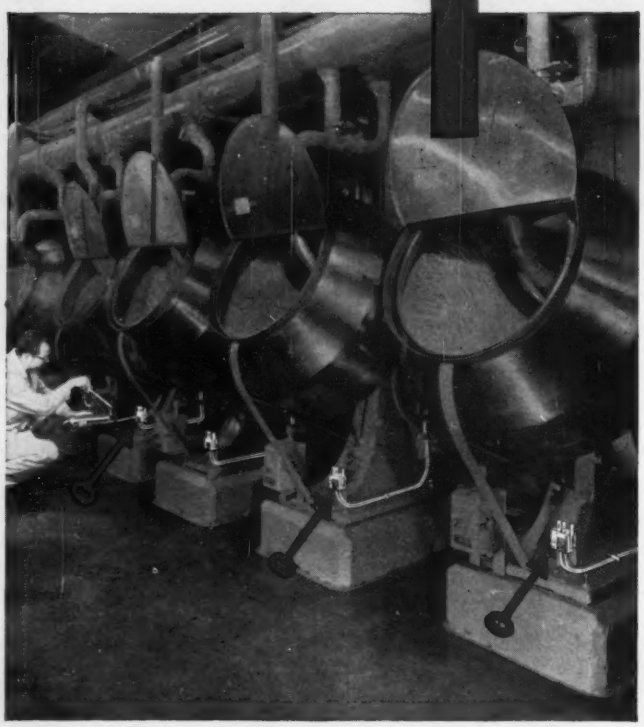
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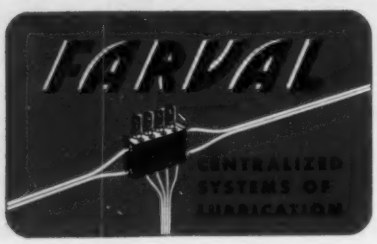
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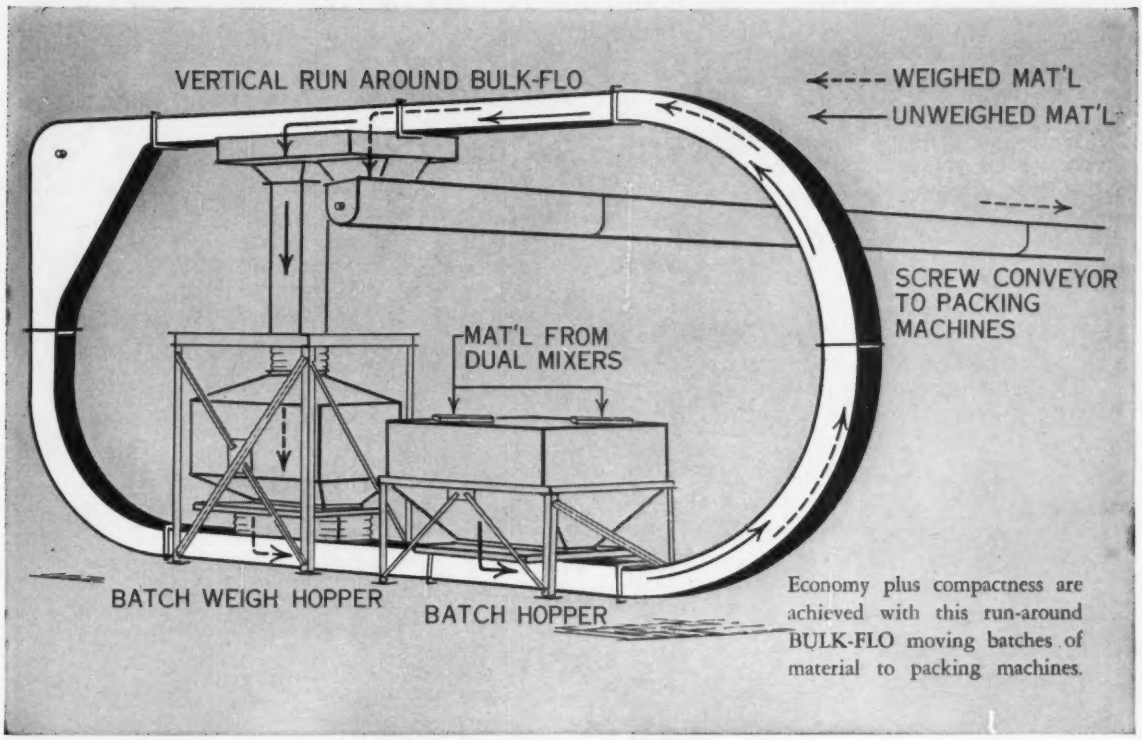
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KEYS TO ADEQUATE LUBRICATION—Wherever you see the sign of Farval—the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.

Farval Multival System lubricates equipment dependably in the tablet coating room of Abbott Laboratories' modern pharmaceutical plant.



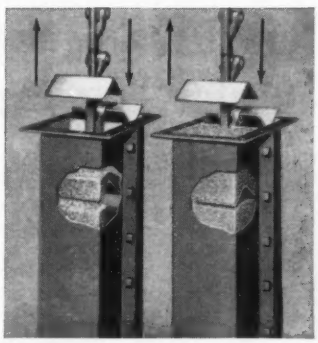


Economy plus compactness are achieved with this run-around BULK-FLO moving batches of material to packing machines.

How a single BULK-FLO unit combines feeding, conveying, elevating

Compact...reduces costs...operates fully or partially loaded

HERE'S a single, fully-enclosed assembly that moves materials vertically, horizontally, on an incline or any combination of these. Often replacing several handling units . . . in less space . . . at lower cost—BULK-FLO has solid flights (see right) that provide individual "compartments" to protect friable materials. You get positive operation whether BULK-FLO is fully or partially loaded. Ask your nearby Link-Belt office for facts or mail the handy coupon for copy of Book 2475.



Fully or partially loaded — Link-Belt BULK-FLO assures positive, gentle movement of materials. Self-clearing through intermediate runs, it prevents contamination.



LINK-BELT

13,742

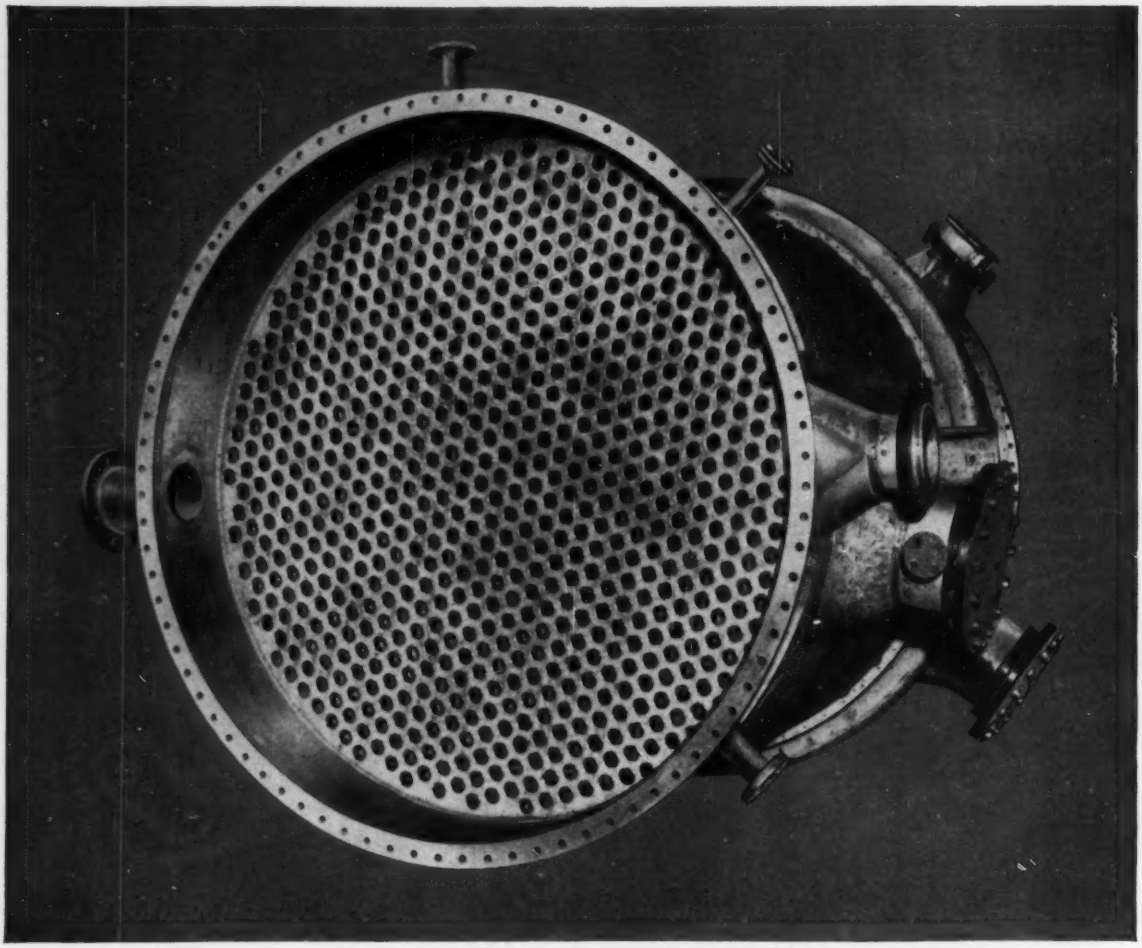
BULK-FLO FEEDERS · CONVEYORS · ELEVATORS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1, To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

LINK-BELT COMPANY
Prudential Plaza
Chicago 1, Ill.
(Or your nearest Link-Belt office)

Please send me immediately a copy of your 28-page BULK-FLO Book 2475.

Name .....
Firm .....
Address .....
City ..... Zone .... State .....



Stainless steel converter—7′ 6″ O.D. by 12′ 6″, face to face of flanges. Equipped with 745 tubes 2″ in diameter by 10′ 0″ long.

How Downingtown Skill and Experience Assure Quality Processing Equipment for Your Plants



Generator air pressure tank built at Downingtown of carbon steel—8′ 0″ I.D. x 23′ 8″ overall. Designed and tested for 200 pounds W.P. End plate approximately 8″ thick.



Aluminum cyclone separator, 6′ 6″ O.D. x 30′ 11″ long. Fabricated at Downingtown of type 52S aluminum.

Fabricating the complex pressure vessels which turn flow charts into profitable process plants has been the specialized business of Downingtown Iron Works for many years. We've accumulated the skill and experience required to fabricate accurate, smooth-working process equipment to meet your specifications. We pioneered in the application of stainless steel and other alloys for corrosion-resistant pressure vessels.

We've developed efficient welding techniques—approved for ASME Code work—which assure sound, neat, extra-strong welds. We're skilled at working and welding many alloys and clad steels, as well as the carbon steels and stainless steels. Our new bulletin PF pictures dozens of chemical process pressure vessels fabricated at Downingtown. Write for your copy today.

DOWNINGTOWN IRON WORKS INC.

Hackney

Downingtown Iron Works, Inc.

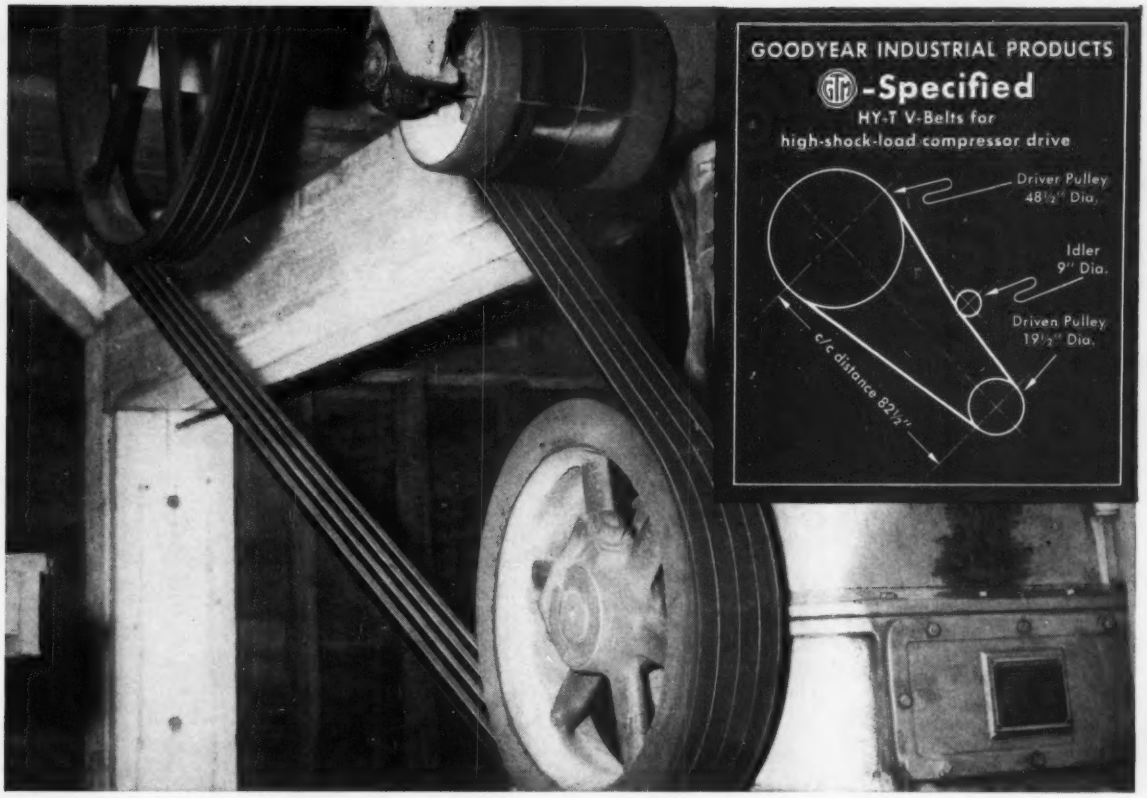
140 Wallace Ave., Downingtown, Pennsylvania

New York Office: 52 Vanderbilt Avenue, New York 17, N. Y.

HEAT EXCHANGERS—TOWERS—PRESSURE VESSELS—STORAGE TANKS
STEEL AND ALLOY PLATE FABRICATION

DIVISION OF: PRESSED STEEL TANK COMPANY
Manufacturer of Hackney Products • Milwaukee 14, Wisconsin

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS



Saved the cost of 3 sets of belts

and still going strong on tough compressor drive

BELT-BREAKING problem for a Southern lumber company was overloading on a compressor drive. Frequent and sudden shock-loads kept belt-life down to 6 months, meant costly shutdowns and expensive replacements.

Called in for consultation, the G.T.M.—Goodyear Technical Man—recommended HY-T V-Belts. Their multiple plies of chemically produced 3-T CORD are tempered by Time, Tension and Temperature to eliminate surplus stretch. They can carry 40% greater horsepower loads at speeds from 100 to 6,000 f.p.m.—have maximum resistance to oil, moisture, mildew and static generation.

Result: The HY-T V-Belts easily took the shock-loads in stride and at last report were still running after 24 months—4 times the service life of the standard V-belts they replaced—saving the cost of 3 sets of belts.

If you have drive troubles call in the G.T.M.—the man who knows V-belts best. Contact him through your Goodyear Distributor or by writing to:

Goodyear, Lincoln, Nebraska or Akron 16, Ohio

YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing or Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

Hy-T—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

HY-T V-BELTS with 3-T CORD by

GOODYEAR

THE GREATEST NAME IN RUBBER

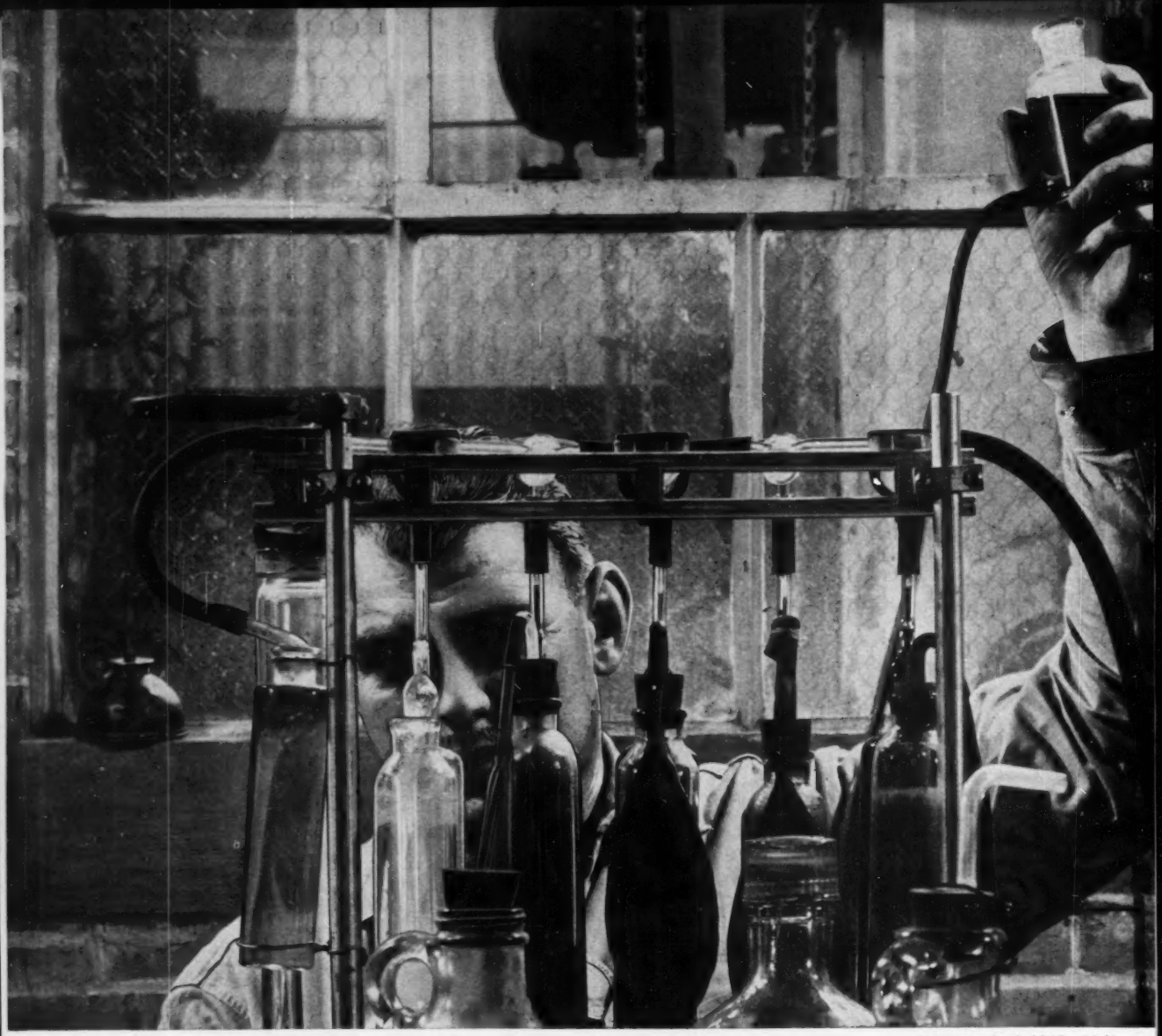


Photo courtesy Standard Oil Co., (N. J.)

boost average ratings as much as 2 octane numbers *with the LJUNGSTROM® AIR PREHEATER*

With waste heat recovered and returned to the furnace in combustion air, the most modern heat-transfer systems can be operated at peak efficiency.

That's why you boost product quality with the Ljungstrom Air Preheater. Its heat-recovery efficiency makes possible advanced furnace designs that assure remarkably close control of processing. And finer control means a more uniform product... with average ratings as much as 2 octane numbers higher. One still's added income just from higher product quality is $58,000 annually.

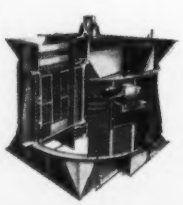
How fast is "WRITE-OFF"?

In earnings from higher octane ratings, many refiners write off the cost of the Ljungstrom installation in less than two years. This time is cut to nine months and even less, when the other Ljungstrom advantages are taken into account – saves up to 20% in fuel costs... permits more economical furnace design, with no need for convection surfaces... burns many fuels you used to throw away... results in consistently higher through-put... and minimizes slag.

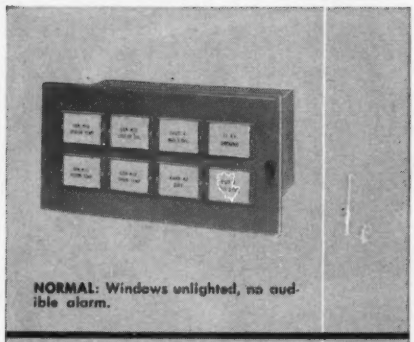
For more complete details on what the Ljungstrom Air Preheater can do for you... for an analysis of the heat recovery benefits obtainable in fuel burning equipment – call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljundstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



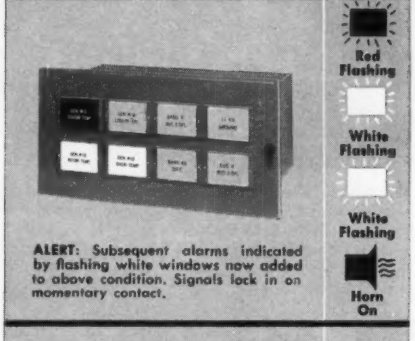
The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.



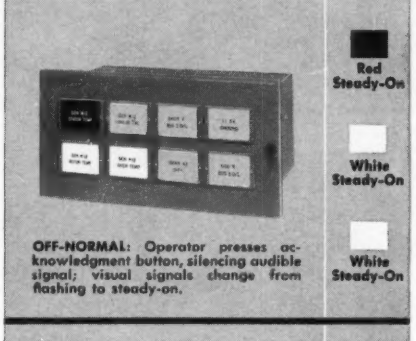
NORMAL: Windows unlighted, no audible alarm.



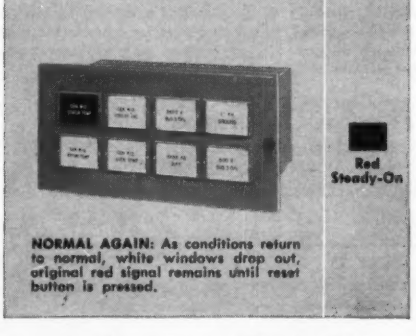
ALERT: Window of first off-normal flashes red; audible alarm. First alarm identifiable with a time difference small as 15 milliseconds between first and following alarms.



ALERT: Subsequent alarms indicated by flashing white windows now added to above condition. Signals lock in on momentary contact.



OFF-NORMAL: Operator presses acknowledgment button, silencing audible signal; visual signals change from flashing to steady-on.



NORMAL AGAIN: As conditions return to normal, white windows drop out, original red signal remains until reset button is pressed.

Panalarm "VS" Annunciator identifies first off-normal from subsequent alarms for rapid corrective action

You gain the control advantages of an audio-visual information system, not just an alarm system, with the Panalarm "50VS" Visual Sequence Annunciator. This is particularly valuable when one off-normal condition will cause a "chain-reaction" of off-normals. Typical Panalarm applications are found in the process industries and among users of automatic machinery.

The original off-normal is clearly identified, enabling the operator to take immediate, corrective action. A considerable saving in down-time can often be effected simply by knowing the original source of trouble.

Panalarm "50VS" is completely flexible in setting up various sequential groups. Any number or combination of signals may be grouped as an independent sequence, and the groupings may be changed at any time by simple jumpers on the terminal block. Signals may be either illuminated nameplate or bullseye indicators, combined with a horn, bell or other audible signal. Signaling is simple and positive. A typical sequence is illustrated on the left.

Write for literature on the "50VS" and other Panalarm Annunciator Systems. A Panellit sales engineer will be happy to make a survey of your production operation to determine whether a Panalarm system can help increase efficiency and safety in your plant.

All Panalarm Annunciator Systems are completely modular, permitting future growth and changes. The photographs below illustrate a typical Panalarm Cabinet with illuminated nameplates and the hermetically sealed Panalarm "50" plug-in relay unit. Components throughout are ruggedly built to instrument standards for continuous, dependable duty. Entire Panalarm system is suitable for Class 1, Division 2 installations.





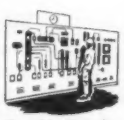
Listed by Underwriters' Laboratories

U.S. Patent No. Re-24,031

Engineered Information Systems for Industry



Panalog Information Systems



Graphic Panels Control Centers



Instrument Services Division

PANALARM

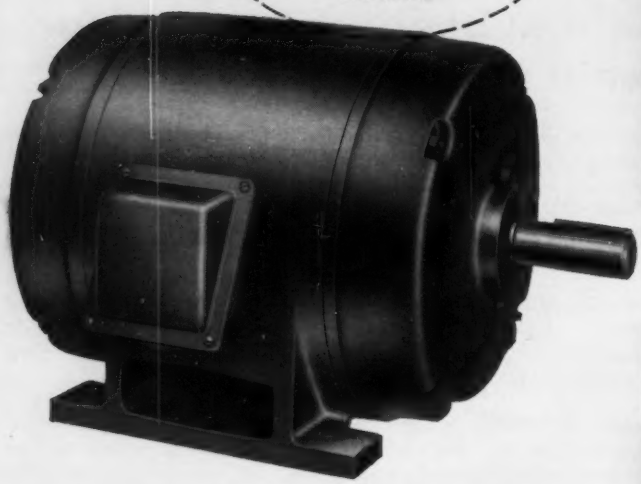
Division of

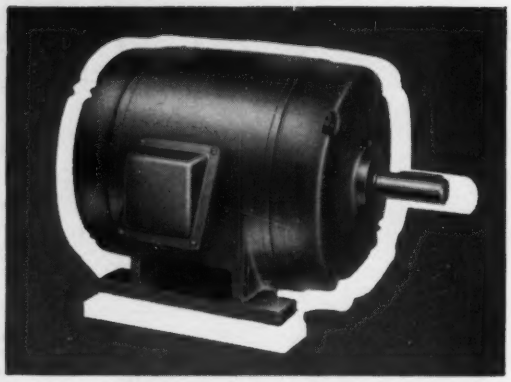
PANELLIT, INC.

7413 N. Hamlin Ave.
Skokie, Ill.

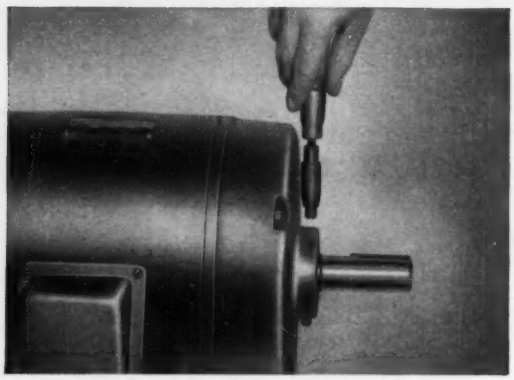
Panellit of Canada Ltd. Toronto 14

Wagner®
ELECTRIC MOTORS
...the choice of leaders in industry

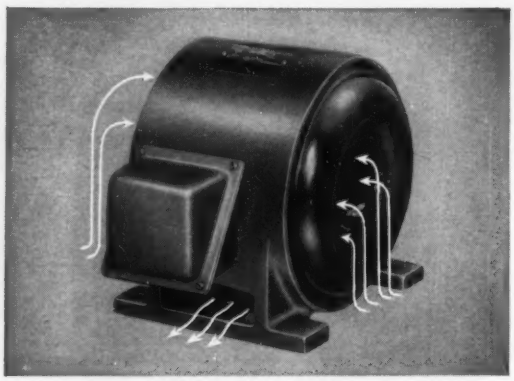




MORE POWER IN SMALLER FRAMES The Wagner DP Motor packs more power in a smaller frame and this smaller size means ease of handling and stocking... less space required for installation.



CAN BE RE-GREASED FOR LONGER LIFE This motor will operate for years without regreasing... bearings are completely enclosed ...however, provisions have been made for adding lubricant and for the removal of old grease in cases where re-greasing is necessary.



COOL RUNNING Specially designed baffles direct cooling air from the blowers through the motor and provide protection for the stator windings. Blowers are an integral part of rotor... and move large volumes of air without noise or vibration.

You get better performance with these Wagner DP Motors

Wagner DP motors are *doubly protected* by (1) rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity. (2) Enclosures on the DP motor are completely drip-proof—virtually splashproof. Air intakes are located at the bottom of the endplates and air outlets are located at the base of the frame—one on each side.

Although engineered to meet the re-rated NEMA specifications which call for more power in smaller frames, the same high quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many years has of course been retained.

Full information and principal dimensions are given in Bulletin MU-202. Write for your copy today.



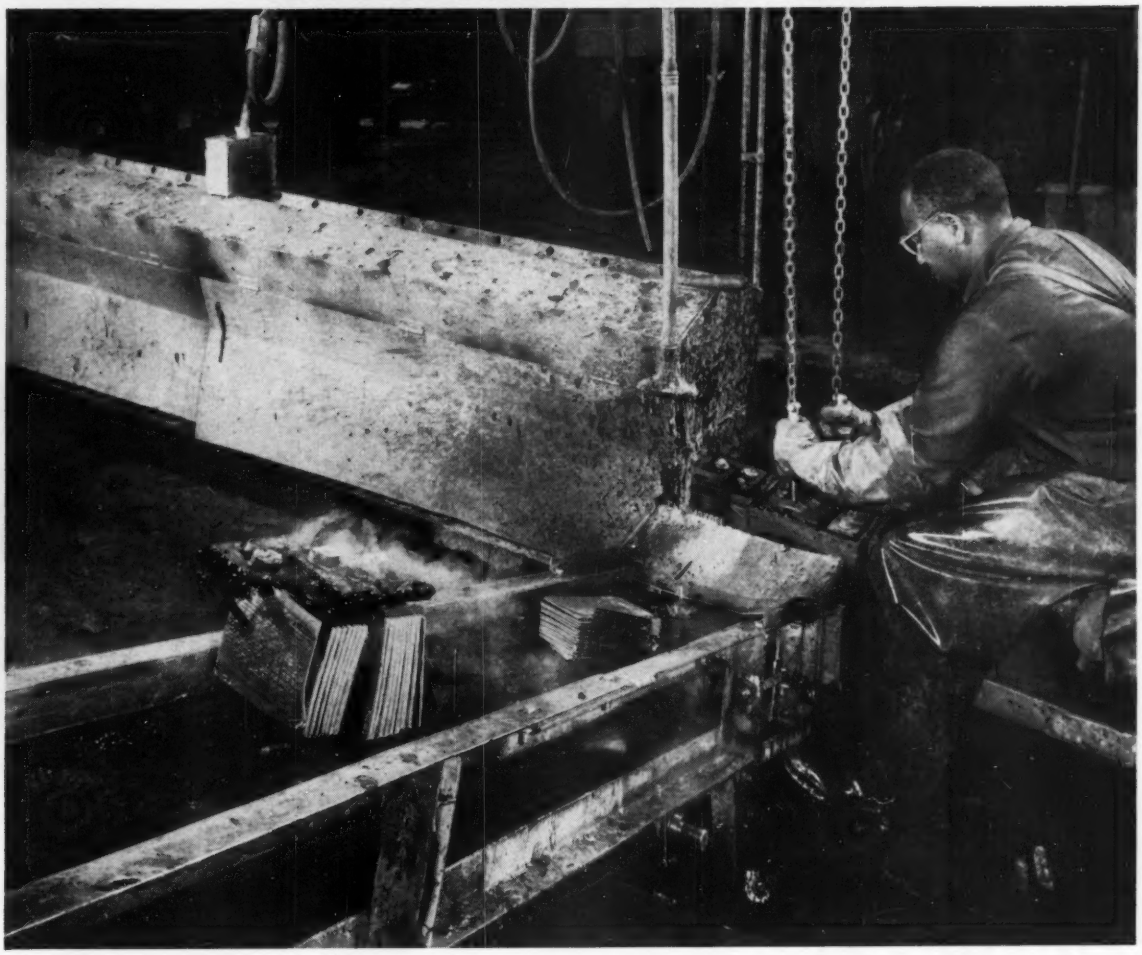
Wagner Electric Corporation
6407 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M56-4

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER



Hot lead rides rubber, drenched in acid, tar, water

A typical example of B. F. Goodrich improvement in rubber

THAT'S the way they salvage old automobile batteries. High heat softens the outer case and tar so the lead plates can be taken out, melted down and used again. But how carry anything through the salvage plant, dripping with sulphuric acid, hot tar and water?

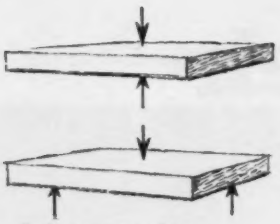
A conveyor belt was tried, but burned out in a few months. Other belts, specially designed for hot materials, averaged only 6 to 8 months. Then the company tried a B. F. Goodrich *cord* belt. It's made with cords, running lengthwise, held in place by a new, heat-resisting rubber.

This improved B. F. Goodrich belt is what you see in the picture. It has already outlasted—by 50%—any other belt ever used here. And it's still in such good condition, engineers predict it will give several years more service.

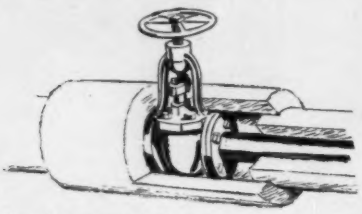
Besides standing higher temperatures, the cord belt can take crashing blows that would cut, gouge and break an ordinary belt. And if an accident should cause a cover cut, there are no cross threads to spread acid that would weaken or rot the belt. The rubber surrounding each cord restricts moisture to the cut spot.

B. F. Goodrich engineers are constantly finding ways to make rubber products save money for users—either by doing a job other rubber can't do, or by lasting longer, or by replacing other more expensive materials. Your B. F. Goodrich distributor can show you, right in your own plant, where these improvements can cut your operating costs. Call him when you need rubber. *The B. F. Goodrich Company, Dept. M-572, Akron 18, Ohio.*

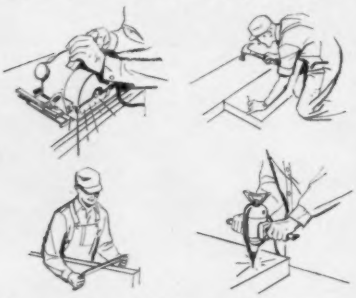
B.F.Goodrich
INDUSTRIAL PRODUCTS DIVISION



Unequaled compressive and flexural strength!



Can be removed for easy line inspection . . . replaced without damage, waste!



Saw it . . . nail it . . . shave it . . . drill it!

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INDUSTRIAL INSULATIONS

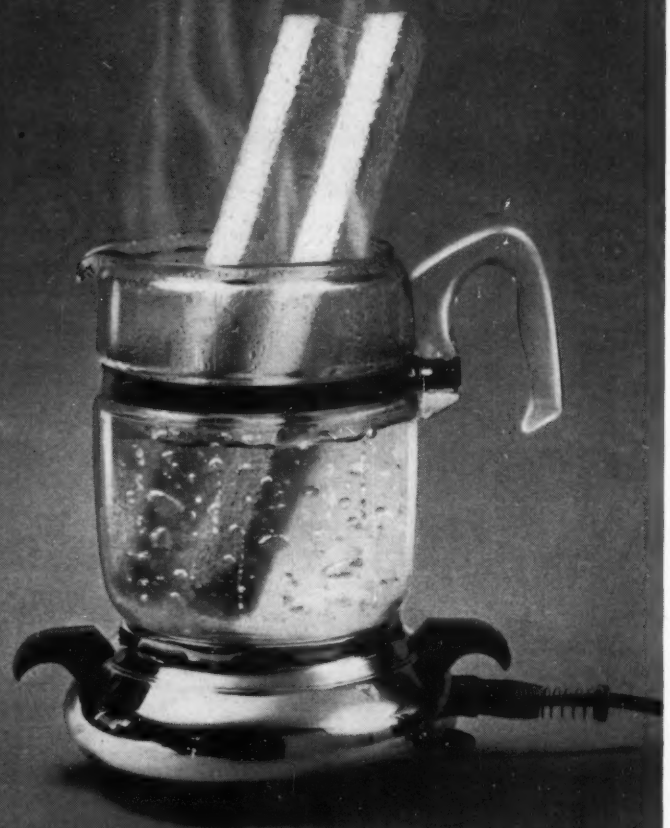
. . . distributed by approved Fiberglas distributor-contractors . . . offer the most versatile family of plant insulations available. With new *pink* Kaylo-*20* (increasing the upper range of Kaylo by 600°F.!), you can now order—from *one* reliable supplier—complete insulation coverage *from lowest sub-zero to 1800° F.*, serving such extra-high temperature applications as catalytic cracking units, refractory wall backing for furnaces and boilers, and fireproofing of piping, equipment, and vessel skirts. See *Sweet's Files*, *Chemical Engineering Catalog*, or *Refinery Catalog*. Or write: Owens-Corning Fiberglas Corporation, Dept. 97-C, Toledo 1, Ohio.

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*T-M. (Reg. U.S. Pat. Off.) Owens-Corning Fiberglas Corporation
® T-M. Reg. Owens-Illinois Glass Co., Inc., mfr. of Kaylo

Specify KAYLO®

Heat Insulation



for stability!

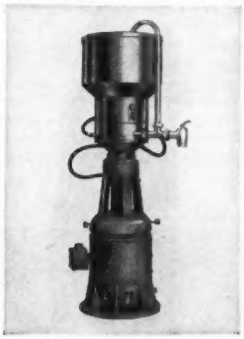
AN IMPORTANT MESSAGE TO OUR MANY FRIENDS...

GIFFORD-WOOD CO.
Hudson, New York

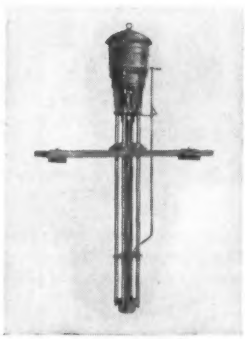
manufacturers of equipment for the
processing industries since 1814
takes pleasure in announcing
that they now manufacture and distribute
the complete line of

Eppenbach Processing Equipment

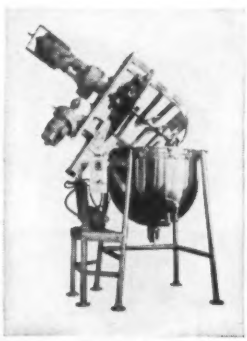
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For complete information write or phone: GIFFORD-WOOD CO., 420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

Life
on the Chemical Newsfront





(Above) **NORMAL GROWTH** is not possible without Folic Acid, an essential factor in the formation not only of red blood cells but all body cells. Everyone needs it daily. During periods of rapid growth, as in infancy and pregnancy, there is an increased need for this rare vitamin. Recognition of Folic Acid's importance has led to its wide use in B-complex and multivitamin preparations. Recently Cyanamid introduced to the drug trade an improved product containing a minimum of 93% anhydrous Folic Acid, the highest potency yet attained commercially. **(Fine Chemicals Division)**

(Left) **NEW HIGHS IN HIGHWAY CONSTRUCTION** are forecast this year, with contract volume expected to rise 17% to $2½-billion. The spread of highways and superhighways over every type of terrain presents titanic earth-moving tasks. In leveling hills to smooth the motorist's way, and quarrying rock for paving materials, Cyanamid explosives and blasting supplies will play a big part. Among Cyanamid products serving contractors are high explosives and precisely timed electric blasting caps that help insure good breakage and reliable results. **(Organic Chemicals Division)**



A UNIQUE NEW SYSTEMIC HERBICIDE, Amino Triazole, selectively kills a number of perennial weeds. While most herbicides kill by contact, Amino Triazole enters the sap system and spreads to all parts of the plant. It suppresses growth and unbalances the chlorophyll-producing mechanism, ultimately killing roots. Canadian thistle is among plants susceptible to Amino Triazole. *Photo left* shows typical whitening or chlorosis of new growth one week after spraying. *Photo right* shows how Amino Triazole is translocated into roots; this stunted white plant was sent up from root system of parent plant that was sprayed. Among other noxious perennials that can be controlled are quack grass, nut grass, ash, scrub oak, poison ivy, poison oak, rushes, and Russian knapweed. **(Agricultural Chemicals Division)**



Women's work makes chemical markets



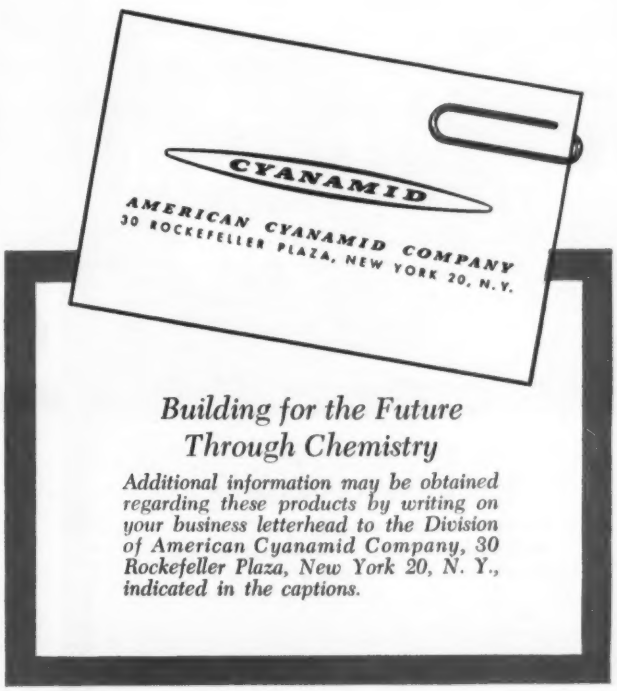


(Above) **HER NEW CLOTHESLINE IS PAPER!** Plymouth Cordage Company, Plymouth, Mass., now produces Fibre-White Clothesline of MELOSTRENGTH® Paper. This paper is treated with MELOSTRENGTH® Resin, which makes a water-insoluble bond between paper fibers. The paper is stronger, wet or dry, has high wet-rub resistance so it may be wiped clean easily. And it resists chafing of clothespins through wet laundry. This economical clothesline is one of many improved paper products made possible by MELOSTRENGTH Resin. **(Industrial Chemicals Division, Department B)**

(Left) **AND HER LINENS COME WHITER,** thanks to triazine-type brighteners based on AERO® Cyanuric Chloride. These optical bleaching agents absorb ultraviolet radiation and emit it as visible wave lengths in the blue portion of the spectrum. This fluorescence counteracts yellowish or greyish soil, and increases the total light reflectance of the fabric, making it brighter as well as whiter. Optical brighteners also lighten pastel shades and increase color contrast in printed goods. Many other triazine dyestuffs have been derived from cyanuric chloride, which can also be used to make plastics of exceptional clarity and heat resistance, fungicides and insecticides, vulcanization accelerators and surface active agents. **(Industrial Chemicals Division, Department B)**
*Trade-mark



NEW AMINE HELPS WAX SHED WATER. Wax emulsions made with 3-methoxypropylamine, a volatile amine derived from acrylonitrile, give highly water-resistant films. Laboratory tests indicate that 3-methoxypropylamine will replace two to four times the amount of morpholine required in similar formulations. To prepare an almost transparent emulsion with fine gloss, Dura Commodities Corp., New York, N. Y., suggests this formula: 40 parts Duroxon J-324 mineral wax, 3 to 4 parts oleic acid, 3 parts 3-methoxypropylamine, and water. Emulsifying and dispersing action is equal to or better than that of morpholine, and similar results might be expected for other wax formulations. **(New Product Development Department, Section B)**



WHAT'S THE PRICE OF THIS AGITATOR?



There are three "price tags" that add extra value to the purchase price of a Nettco Agitator. These are:

The engineering "price tag" — your assurance the Nettco drive is the right size, the right speed, the right horsepower, the right shaft diameter — backed by Nettco's over 50 years of serving the agitation needs of Industry.

The operating "price tag" — your assurance the Nettco unit is engineered for low power consumption and high productivity — two vital economy factors in any processing system.

The maintenance "price tag" — your assurance the Nettco drive will minimize maintenance: with a minimum of moving parts — all conservatively rated.

Next time use Nettco — for engineered agitation that's lowest cost in the long run. Send for data and recommendations, to New England Tank & Tower Company, 87 Tileston St., Everett 49, Mass.





Installation of Nettco Agitators in new multi-million dollar dyestuffs plant — **complete plant served by Nettco Engineered Agitation.**

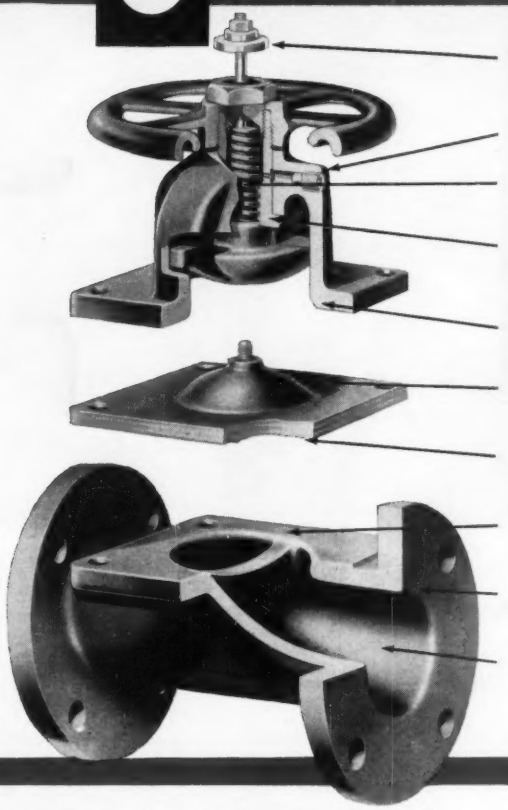
HELPFUL NETTCO CATALOGS

General Catalog No. 551
Side Drive Agitators, Bulletin No. 532
Nettco Flomix®, Bulletin No. 531

NETTCO
ENGINEERED AGITATION

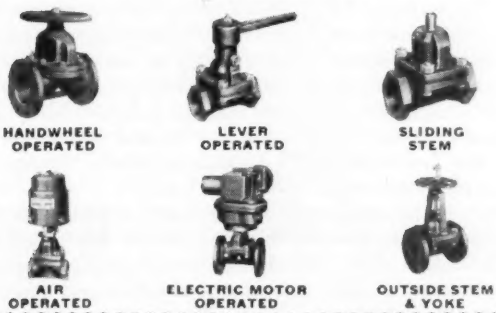
WITH ONLY **3** **SIMPLE COMPONENTS**

Hills-McCanna Diaphragm Valves offer all these outstanding features for handling corrosives



1. **TELL-TALE TRAVEL STOP** shows position of diaphragm; prevents possible damage to diaphragm that could result from overclosure.
2. **CHOICE OF 36 BONNET ASSEMBLIES** assures a means of operation best suited to your requirements.
3. **SUPERIOR MECHANICAL DESIGN** transmits closing force to the compressor through a long, full-threaded special bronze sleeve.
4. **WORKING PARTS ISOLATED FROM FLOW** by means of the diaphragm. Similarly, the fluid handled is not contaminated by bonnet lubrication, products of decomposition or atmospheric contamination.
5. **NO PACKING** to be replaced. The diaphragm effectively seals the bonnet assembly from the flow.
6. **TOUGH, RESILIENT, REINFORCED DIAPHRAGM** in a choice of 14 materials permits handling of over 1000 industrial chemicals.
7. **POSITIVE, LEAK TIGHT CLOSURE** is assured by sealing beads on diaphragm and cushioned pressure seating of the diaphragm against the weir.
8. **SIMPLE MAINTENANCE** is limited to occasional diaphragm replacement which can be done without removing valve body from line.
9. **CHOICE OF BODIES** is very wide, including any machinable alloy, molded plastics or linings of rubber, glass, lead or plastic.
10. **SELF-CLEANSING** characteristic is made possible by absence of pockets, corners, grooves and sharp changes in direction.

A COMPLETE CHOICE OF METHODS OF OPERATION TO SUIT YOUR REQUIREMENTS



• Hills-McCanna diaphragm valves are offered in sizes from ⅜" through 14". Dependent on size and type of body and diaphragm materials, they will handle pressures to 150 psi, temperatures to 350° F. For specific recommendations, send an outline of your corrosion resistant valving problem. To have full data at hand, ask for the Hills-McCanna valve catalog.

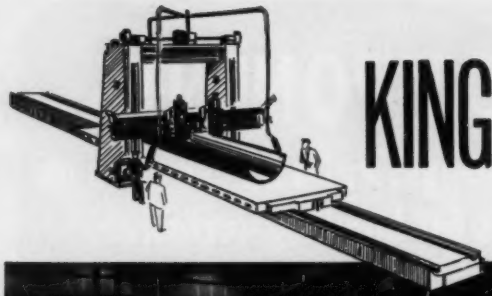
HILLS-McCANNA CO.

2341 W. Nelson St. Chicago 18, Illinois

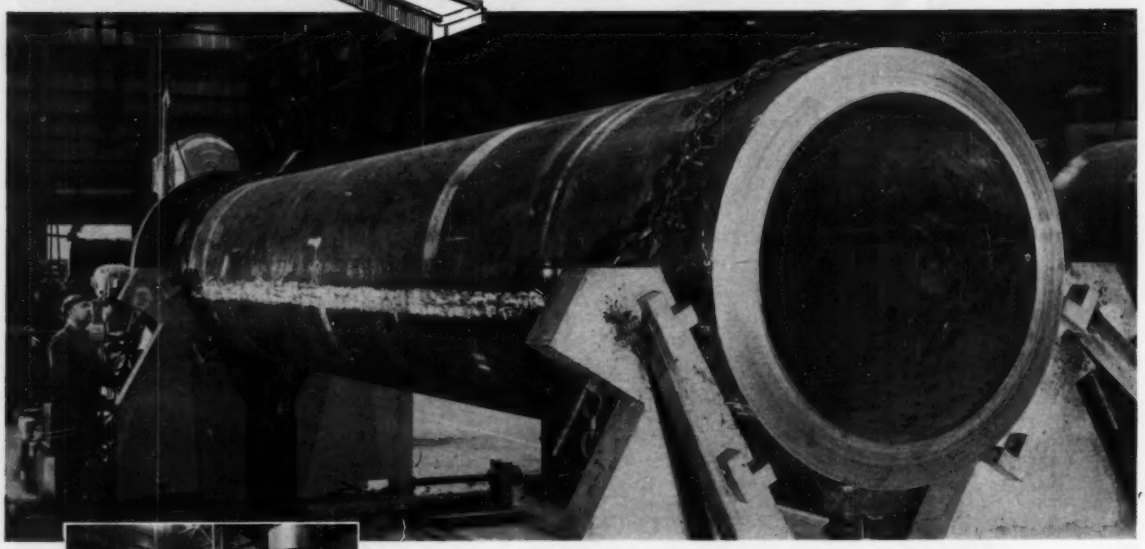
Manufacturers of: Saunders Patent Diaphragm Valves • Chemical Metering and Proportioning Pumps • Force Feed Lubricators • Light Alloy Castings

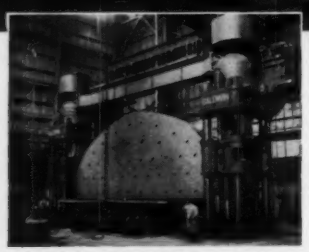
HILLS-McCANNA

Corrosion Specialists Since 1870

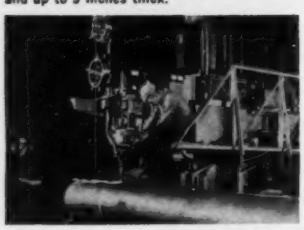


KING SIZE PRESSURE VESSELS

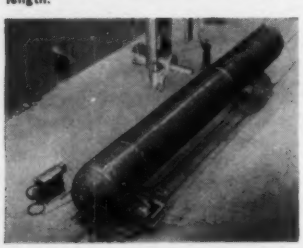




This 8,000 ton hydraulic beam press at Mountaintop can bend steel plate 39 ft long and up to 9 inches thick.



Twin-arc welding units on traveling booms permit welding of vessels up to 8 inches thick, 12 ft in diameter and any desired length.



Two-million-volt X-ray generator penetrates steel up to 12 inches thick – permits rapid inspection of welds for detecting flaws, holes or scale.

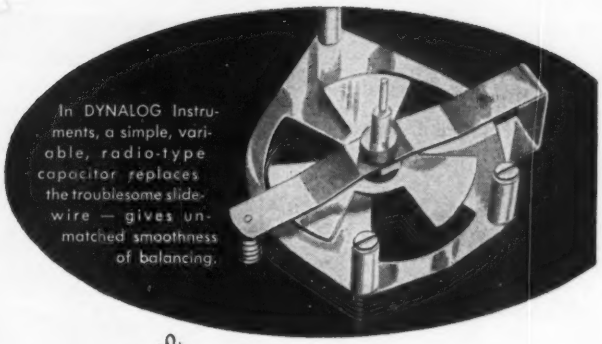
. . . demonstrate exceptional capacity of FW fabricating facilities

THE photo above shows a final machining operation on one half of a 48-foot high-pressure vessel fabricated at Foster Wheeler's new Mountaintop, Pa. plant. Another of these solid steel vessels now on order is 36 ft long, 4 ft in diameter, with a wall thickness of *5 inches*. It will be constructed of two half shells, bent on the 8,000 ton beam press from 5-inch steel plate 36 ft long. The two halves will be welded together and machined to form the completed cylinder.

With metal forming, welding and machining facilities of exceptional size and capacity, located in large modern plants at Carteret, N. J., Dansville, N. Y., Mountaintop, Pa. and St. Catharines, Ontario, Foster Wheeler offers a unique fabricating service to industry. High pressure vessels, pressure piping and unusual weldments to Code requirements and beyond, can be produced by the most modern and efficient methods, with substantial savings in time and cost.

Write today for complete information on FW fabricating facilities. We will be glad to quote on your specific requirements. *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

FOSTER WHEELER



In DYNALOG Instruments, a simple, variable, radio-type capacitor replaces the troublesome slidewire — gives unmatched smoothness of balancing.

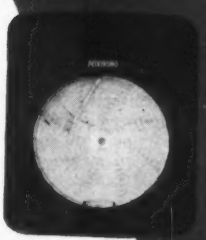
This potentiometer has no slidewire

STEPLESS CAPACITY-BALANCING

ELIMINATES SLIDEWIRE MAINTENANCE

DYNALOG'S* EXCLUSIVE BALANCING ACTION

- no slidewire
- no batteries
- no standardizing
- no gears, cables, etc.
- no high-speed reversing motor



There's no need to put up with worn slidewires and sticking electrical contacts . . . no need to periodically clean and lubricate balancing motors. DYNALOG design eliminates all this! Its simple variable capacitor and positive magnetic drive provide *continuous, stepless* balancing . . . *never* require attention!

DYNALOG's friction-free action provides high speed of response without wear. (There are only five moving parts, including the recording pen!) Sensitivity, unlimited by turns of slidewire winding, is 1/100 of 1%. And accuracy is a sustained 1/4 of 1%.

DYNALOG Instruments are available for use with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable . . . with unmatched smoothness. Write for Bulletin 343. The Foxboro Company, 369 Neponset Ave., Foxboro, Mass., U.S.A.

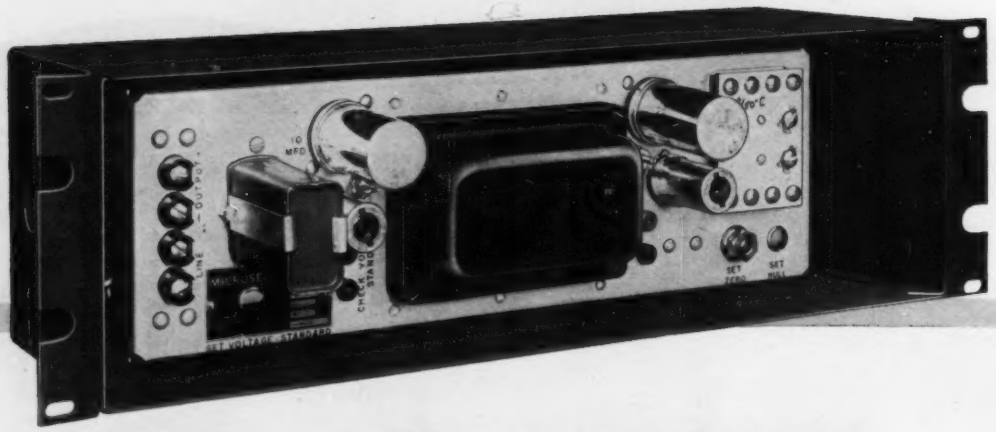
*Reg. U.S. Pat. Off.

FOXBORO

*Reg. U.S. Pat. Off.

DYNALOG

ELECTRONIC INSTRUMENTS



NEW TRANSMITTING POTENTIOMETER OFFERS 7 BIG FEATURES

★ **Extreme sensitivity. Responds to input change of 3 microvolts or less.**

★ **Self-contained continuous voltage reference. No standard cells.**

★ **No batteries or periodic standardization. Continuous accuracy without drift.**

★ **Simple circuitry. Only 2 single triode tubes.**

★ **Interchangeable range card. Ranges easily changed in the field.**

★ **No slide wires or choppers. Trouble-free operation.**

★ **Fast response: 0.04 second time-constant for 1000° F. span.**

The Series 184 Transmitting Potentiometer is the latest addition to the 'American-Microsen' System of Electronic Transmission and Process Control. With this new unit, it is now possible to measure and control thermocouple temperatures or the signals from such devices as pH amplifiers, gas analyzers, resistance thermometer elements, and other electrical systems.

The extreme sensitivity of the new Potentiometer, plus the high resolution and response speed of the 'American-Microsen' Control System, makes it possible to control process temperatures with the high accuracy required by present-day production demands.

The 0.5 to 5.0 ma. signal output can be transmitted 30 miles or more, over a single 2-wire circuit. In addition to 'American-Microsen' receiver, the signal will operate standard d-c milliammeter indicators and recorders.

OPERATING SPECIFICATIONS

Spans: 6 to 50 millivolts d-c.
Suppression: Up to 5 times span.
Output Signal: 0.5 to 5.0 ma. d-c.
Sensitivity: 0.003 millivolts (0.1° F.).
Repeatability: 0.02 millivolts. (0.6° F.).
Input Source Impedance: 200 ohms maximum.
Effective Input Impedance: 1000 ohms per millivolt of span.
Output Load Impedance: 3000 ohms maximum.
Speed of Response: 0.8 seconds for 99% response on 6 millivolt span. Speed increases with span.

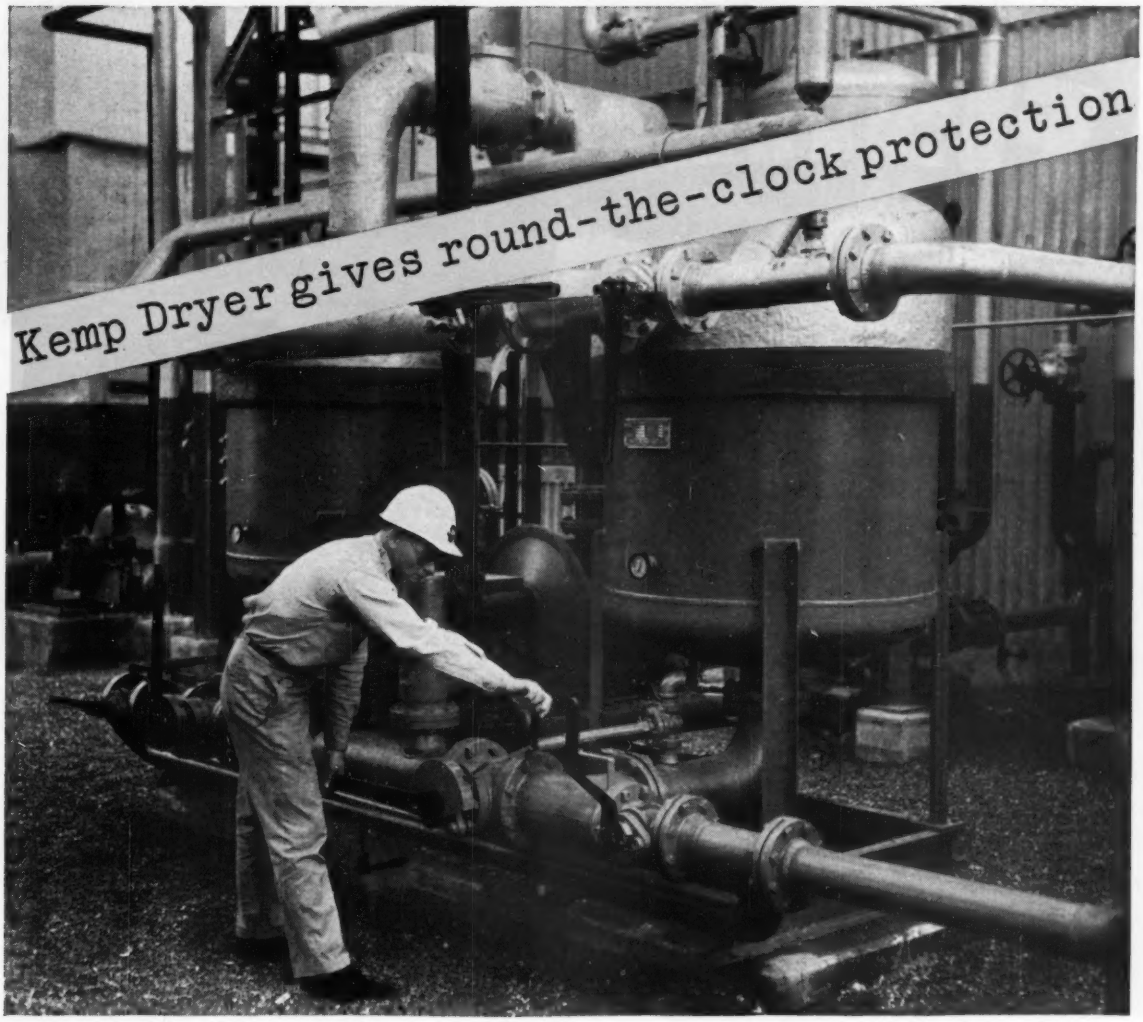
Write today for Bulletin MTT810.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M MOORE INC TRADE MARK

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF THE 'AMERICAN-MICROSEN' TRANSMISSION AND PROCESS CONTROL SYSTEM, 'AMERICAN-MICROSEN' ELECTRO-PNEUMATIC TRANSDUCERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.



Grace Chemical Company Reports: *Kemp Dryer safeguards instruments throughout plant 24 hours per day*

The Grace Chemical Co. manufactures Anhydrous Ammonia and Urea 24 hours a day at Woodstock, Tenn. This operation demands instrument accuracy with a minimum of maintenance and downtime. To increase instrument efficiency by preventing corrosion and costly line freezes, Grace Chemical installed a Kemp Dryer.

Kemp Requires Little Attention

Semi-automatic, the Kemp Dryer works night and day drying compressed air for instruments and pneumatic controlled valves. According to operator Charles Lewis, the Kemp unit requires a bare minimum of attention.

Kemp Dryers for Every Purpose

Kemp offers a variety of dryer models to meet all problems. Designed to dry air, gases or liquids to sub-zero dew points at a low cost, they are constructed of quality materials and embody the engineering knowledge gained from Kemp's many years of experience. Kemp Dryers are available with manual, semi-automatic, or fully automatic tower reactivation. In addition, Kemp will prescribe the proper desiccant for each drying job. If you have a problem involving the removal of water from air, gases, or liquids, contact Kemp engineers now. For complete facts and technical information, write for Bulletin D-29.

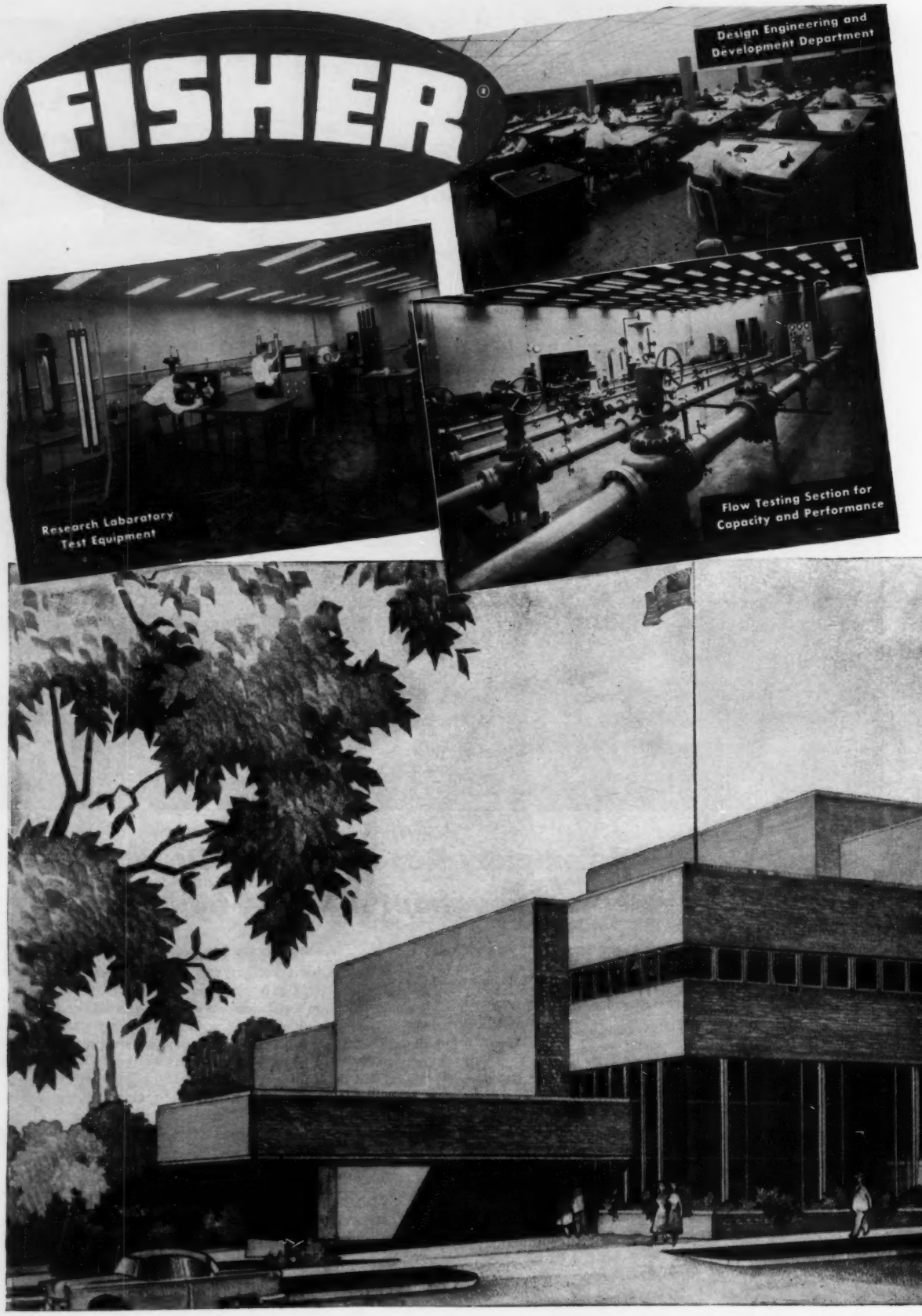
KEMP OF BALTIMORE



DYNAMIC DRYERS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • INERT GAS GENERATORS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland


FISHER
Design Engineering and Development Department
Research Labaratory Test Equipment
Flow Testing Section for Capacity and Performance

to Serve You Better. . .

Fisher Governor Company has built the industry's most modern and completely equipped engineering, research and administration building.

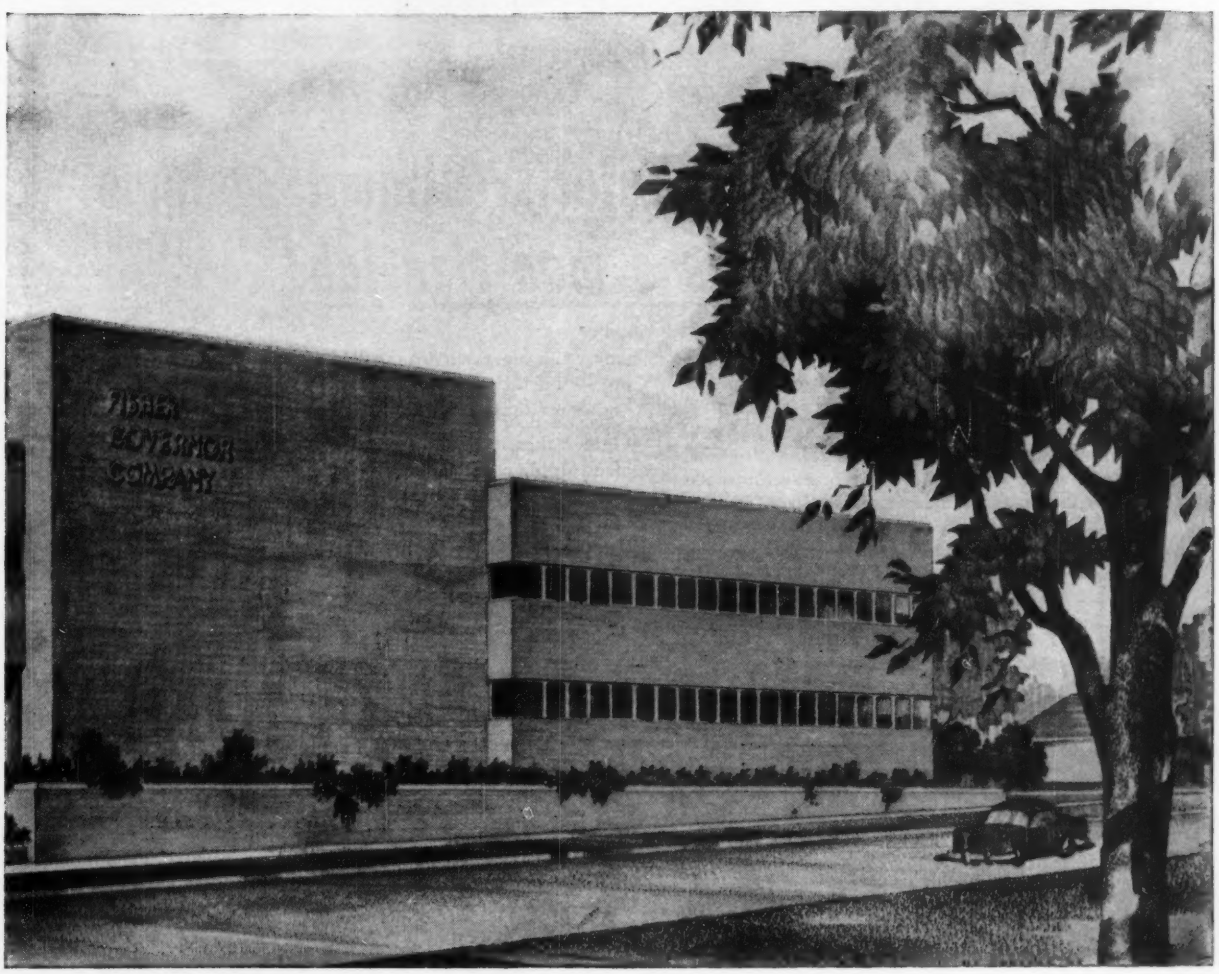
These new facilities—occupying over 100,000 square feet of space—make possible better coordination and greatly expanded engineering and research activities, so as to provide you the world's finest automatic control equipment. A series of test lines up to 12" diameter are located in the research laboratory. Performance tests are run on Fisher products at pressures up to 2500 psi, using air or water as flowing medium.

The enlarged product engineering department is located adjacent to the research laboratory area. Sales engineering and administrative offices are also in the new building.

FISHER GOVERNOR COMPANY • MARSHALLTOWN, IOWA

CANADIAN PLANT: WOODSTOCK, ONTARIO

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL





Building Water Treatment Systems *is a man-size job!*

Having been in the water conditioning business for nearly fifty years, we know that *every* water treatment job is a challenge. In this business, you can't send a boy to do a man's work.

Since 1908, Elgin has been designing, building and installing water conditioning equipment for thousands of purposes in hundreds of industries, institutions, municipalities and commercial establishments. Naturally, during that time, we've built up a backlog of experience and water engineering skill second to none. As a result, the name *Elgin* has become synonymous with superiority in the field of water conditioning — whether softening, dealkalizing, demineralizing, deaeration, degasification, chemical treatment.

Elgin makes it a policy to meet *every* water treatment problem with concentrated attention. You can feel sure — when you bring your problem to us — that all the experience and knowledge at our command will be at your disposal. Talk over your water treatment problems with your Elgin representative. Or write us direct. We *can* help you!

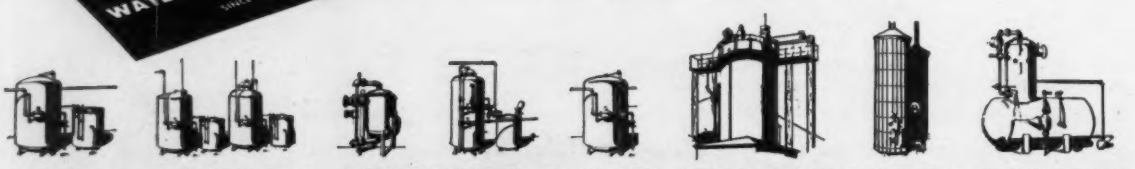
ELGIN WATER CONDITIONING

ELGIN SOFTENER CORPORATION

160 No. Grove Avenue, Elgin, Illinois

Representatives in Principal Cities

In Canada: G. F. Sterne & Sons Ltd., Brantford



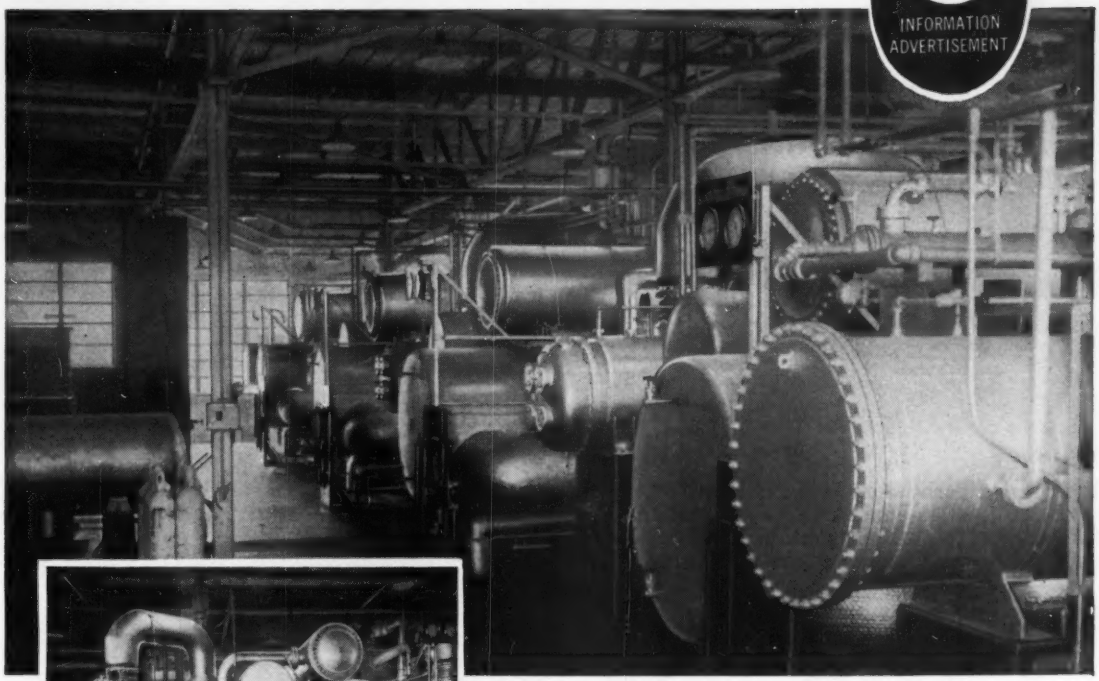
SOFTENERS | ION EXCHANGERS | FILTERS | DEIONIZERS | DEALKALIZERS | LIME COAGULATORS | DEGASITORS | DFAERATING HEATERS

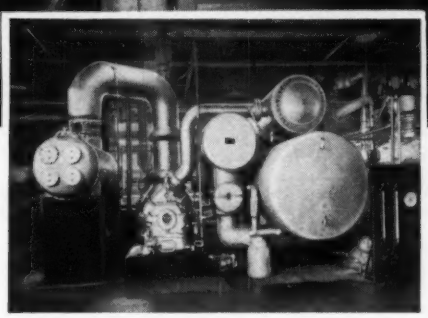
NEW facts for your files on York Turbo Compressors for

Chemical Plants

York refrigeration or air conditioning

INFORMATION ADVERTISEMENT





Four York Turbo Compressors operating on four York Turbo Brine Chilling Systems help keep production and quality at high levels for the Firestone Tire & Rubber Co., Lake Charles, Louisiana. One of these York Turbo Brine Chilling Systems is shown in greater detail in the inset at left. Each York System is capable of producing in excess of 400 TR at a leaving brine temperature of +5° F. The units are also designed to produce 230 TR at a leaving brine temperature of −35° F. Firestone uses these York Systems in the manufacture of cold GR-S rubber. The cold brine is circulated through York-designed coils in each reactor to produce the desired cooling effect.

MORE LOW-TEMPERATURE PROCESSES TODAY—and whether you need dependable, constant-capacity refrigeration on a 24-hour, seven-day-week basis, or have an application where refrigeration loads will fluctuate, York Turbo Compressors will do the job.

LOW-TEMPERATURE PROCESSES HAVE TRENDED LOWER—and York Turbo Compressors provide efficient operation in low-temperature processes down to −125° F. (using "Freon-12").

FLOOR SPACE AT A PREMIUM—and a single York Turbo Compressor may fill all your refrigeration needs. York makes Turbo Compressors, in single- and multiple-stage models, up to 3000 tons capacity with Freon refrigerants. (Models also available for ammonia and hydrocarbon refrigeration duty and for general gas compression service.)

CHOOSE YOUR POWER SUPPLY—York Turbo Compressors may be driven by A.C. or D.C. electric motors, either constant or variable speed, steam turbines or internal combustion engines. You choose the power supply that is most economical for you.

EXTREME FLEXIBILITY—even where constant-speed drive is used, York Turbo Compressors, with their exclusive Pre-Rotation Vanes, permit efficient operation over wide ranges of capacity, using either automatic or manual control.

ENGINEERING ASSISTANCE—York's vast experience in the centrifugal compression field is part of a complete York service available to your designer.

Some Helpful Hints for Chemical Men

1. A temporary replacement for broken peepholes in chemical plant equipment can be made by cutting out the bottom of a Pyrex-type saucepan of blue boro-silicate glass. It can be made to fit perfectly by wet stone grinding.

2. To seal pipes against vacuum or low pressure without shutdown, wrap a split piece of polyethylene tubing around joint, melt with blowtorch to produce seal.

3. Install skid-proof metal plates around reaction kettle manholes to avoid damage to thermal insulation when workers must open the manholes.

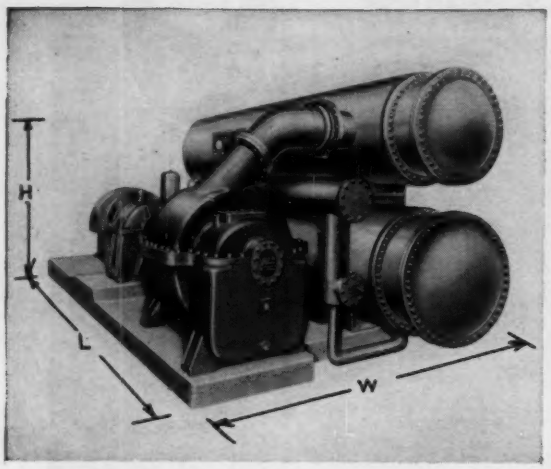
A.I.A. FILE NO. 30-F-22

CUT ALONG THIS LINE AND FILE

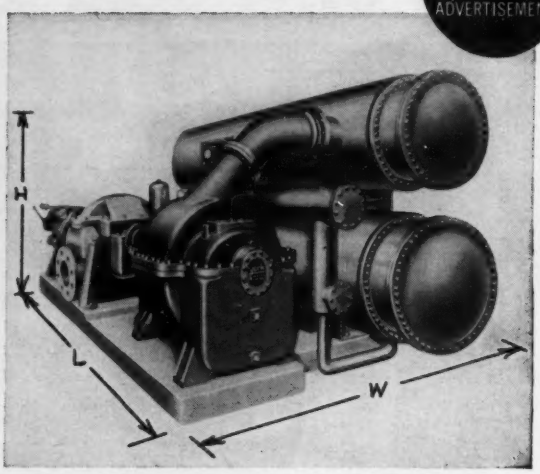
CUT OUT AND FILE—SEND FOR FREE FILE FOLDER AND REPRINTS—SEE OTHER SIDE

YORK TURBO COMPRESSORS

INFORMATION ADVERTISEMENT



MOTOR DRIVE



STEAM TURBINE DRIVE

York Freon Turbo Compressor Systems are particularly adapted to high-capacity refrigeration loads. Their inherent ability to handle large gas volumes permits maximum capacity per unit of floor area, while their vibration-free design permits installation in any convenient location—even on upper floors. These characteristics insure a highly compact and economical installation.

DIMENSIONS

(Depending on model chosen)

Type	"L"	"W"	"H"
Motor Drive	14′6″ to 20′9″	9′9″ to 15′10″	6′8″ to 12′8″
Steam Turbine Drive	14′6″ to 16′0″	9′9″ to 15′10″	6′8″ to 12′8″

NOTE: Dimension "L" will vary with type and size of motor and gear, or with type of turbine. All dimensions are based on 2- and 4-pass shells. Purge device adds 21″ to overall "W" dimension.

PRINCIPAL (AND EXCLUSIVE) FEATURES



IMPELLER. Blades, hub and cover discs are made *entirely* of stainless steel—impeller blades successfully resist erosion . . . the entire wheel resists corrosion —assuring perfect wheel balance during service life. Blades are end milled to form integral rivets, eliminating heads and resulting in unobstructed gas flow and noise abatement.



PRE-ROTATION VANES for maximum capacity reduction. Capacity control is accomplished by changing direction of the rotation of suction gas entering the first stage wheel, thereby changing the characteristics of the wheel. Each change produces the same results as a separate machine of smaller size.



SIMPLIFIED REFRIGERANT SHAFT SEAL prevents gas leakage. Sealing is accomplished by two stationary carbon rings kept always in contact with the shaft seal ring. Seal surfaces are accurately finished and sealed with oil from the compressor lubricating system.



THRUST ABSORBING BALANCE DISC CUTS FRICTION LOSSES. Unbalanced shaft thrust caused by unequal gas pressure on opposite faces of each wheel equalized by balance disc. Need for a heavy duty thrust bearing with attendant higher friction losses eliminated.

York Corporation, York, Pa.

YORK CORPORATION

the quality name in refrigeration

HEADQUARTERS FOR MECHANICAL COOLING SINCE 1885

CUT ALONG THIS LINE AND FILE



*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

To help you in the fight on corrosion...

FIBRES of inert iron silicate distributed throughout high-purity iron make wrought iron *tough* and *corrosion-resistant*... hence a desirable piping material for many applications where corrosion is a factor. In this material too, the "TUBE-TURN"* line of welding fittings is *complete* ... all types, sizes and schedules for every job in wrought iron piping.

Here is another reason it pays to specify this leading brand! You get exactly what you need from more than 4000 items in all piping materials ... available *promptly* from your nearby Tube Turns' Distributor. He can save you purchasing time and delivery time, and give you more for the dollar with TUBE-TURN Welding Fittings and Flanges.

TUBE-TURN Welding Fittings and Flanges are made in U. S. A. They meet *all* U. S. piping code specifications.

The complete line... for all your needs

CARBON STEELS
STAINLESS STEEL
CHROME-MOLY STEELS

WROUGHT IRON

ALUMINUM
COPPER
BRASS
MONEL METAL
INCONEL
NICKEL

Available from your nearby TUBE TURNS' Distributor

TUBE TURNS LOUISVILLE 1, KENTUCKY

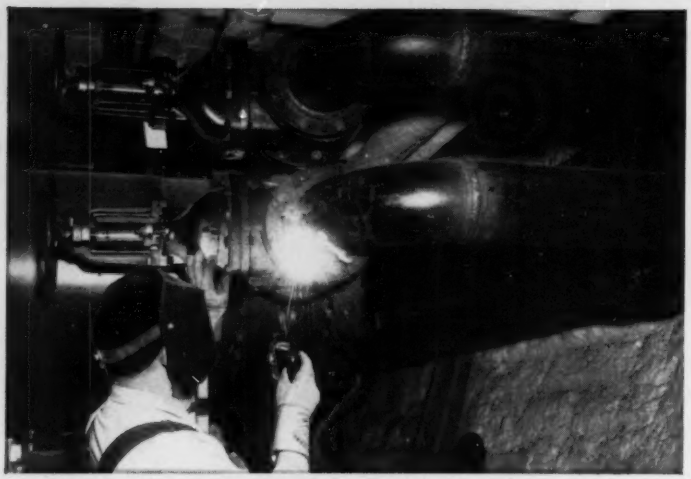
A Division of National Cylinder Gas Company

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Cleveland • Detroit • Chicago • Kansas City • Denver Los Angeles • San Francisco • Seattle • Atlanta • Tulsa • Houston • Dallas • Midland, Texas

APPLICATIONS

TUBE TURNS' *Engineering Service*

helps you apply wrought iron fittings on jobs like these...



Air Conditioning piping . . . wrought iron and TUBE-TURN* Welding Fittings are used for condenser water lines shown here, part of new air conditioning installation at State Capitol Building, Harrisburg, Pennsylvania. Contractors: Riggs Distler & Co., Inc.



Down Spouts on Abbey Avenue Bridge, Cleveland. Made of 10" wrought iron pipe, with 45° TUBE-TURN Wrought Iron Elbows. Contractor: Gorman-Lavelle Co., Cleveland.



Hospital piping . . . wrought iron 5" cold water, 2½" high-pressure condensate returns and 4" pump discharge . . . at City Hospital, Cleveland. TUBE-TURN Wrought Iron Fittings used throughout.



Radiant Heating. Many engineers prefer wrought iron piping for these systems (and snow-removal systems). Shown here: welding in bank of coils to hot water line with TUBE-TURN Welding Tee at Capitol Annex Building, Frankfort, Kentucky. Contractor: B. A. Walterman Co., Cincinnati.



All-around Service. Your nearby Tube Turns' distributor will see that your needs in fittings (of all materials, types and sizes) are met promptly. He will also see that you get Tube Turns' engineering service on your piping applications.

WROUGHT IRON FITTINGS AVAILABLE FROM YOUR NEARBY TUBE TURNS' DISTRIBUTOR



90° ELBOWS



45° ELBOWS



180° RETURNS



TEES



CAPS



CONCENTRIC REDUCERS



ECCENTRIC REDUCERS



FLANGES

APPLICATION DATA

for use of TUBE-TURN Wrought Iron Welding Fittings...

TUBE TURNS, Dept. H-1
224 East Broadway, Louisville 1, Kentucky
Please send Bulletin TT-787 on Wrought Iron Fittings.

Company Name _____

Company Address _____

City _____ *Zone* _____ *State* _____

Your Name _____

Your Position _____



*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh Cleveland • Detroit • Chicago • Denver • Los Angeles San Francisco • Seattle • Atlanta • Tulsa • Houston Kansas City • Dallas • Midland, Texas



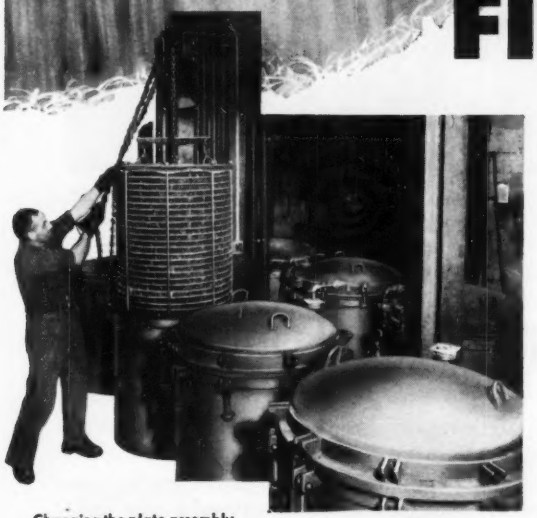
for continuous flow filtration

SPARKLER

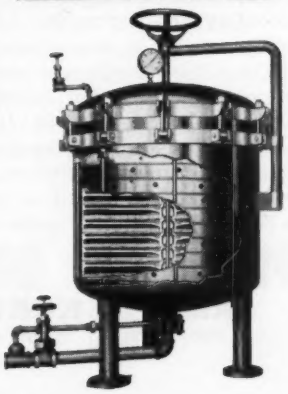
Horizontal Plate

FILTERS . . .

in multiple units with quick-change filter plates



Changing the plate assembly in a Sparkler horizontal filter is quick and easy. The entire assembly can be removed as a unit and replaced with a set of clean plates in a few minutes, cutting filter down time to a minimum.



For fine filtration with low operating cost, specify Sparkler. Assure cake stability, pre-coat economy, complete product recovery, free drainage, and a high flow rate.

Flow need never be interrupted when you have more than one SPARKLER filter on duty. For even during clean up time, flow continues through the remaining operative filter or filters.

And down time for the unit out of service for cleaning is only a matter of minutes, thanks to SPARKLER'S quick-change plate assembly which can be removed and replaced as a complete unit by a single man.

For this reason, when processes require uninterrupted flow during filtration, two or more SPARKLER filters are used with a combined capacity sufficient to meet requirements. If you have a similar filtering application, why not consider doing the same? The simple, economical way of continuous flow filtration.

Filtration engineering and manufacturing exclusively for over 30 years.

SPARKLER
MANUFACTURING CO.
MUNDELEIN, ILL.

Sparkler International Ltd. with plants in Canada, Holland, Italy, Australia. • Service representatives in principal cities throughout the world.



These Speedomax recorders, teamed with Thermal Conductivity Analyzers on the synthesis unit (right), chart final yield (far left), and H_2-N_2 ratio before and after recycle gas enters feed stream.

L&N Analyzers Help The Atlantic Refining Co. Produce Maximum Ammonia Yield Economically

At The Atlantic Refining Company's modern ammonia plant in Philadelphia, peak performance depends on holding a precise hydrogen-nitrogen ratio to the converter, for maximum ammonia yield. A team of L&N Thermal Conductivity Analyzers with Speedomax® recorders handles the vital measuring jobs involved.

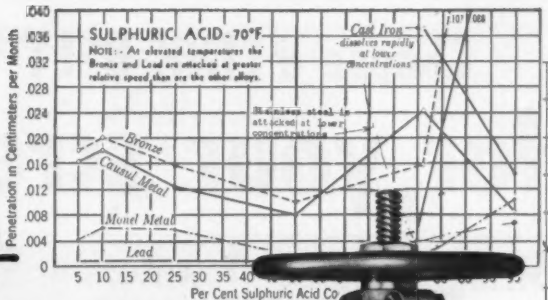
The H_2-N_2 ratio itself is so important that The Atlantic Refining Company operates two identical L&N Analyzers on the feed stream, one before and one after entry of recycle gas. These continuously record H_2 over a range of 65 to 85% while another Analyzer, calibrated 0 to 20% NH_3, records ammonia yield from the converter, and the amount returned in the recycled gas stream.

Feed hydrogen for the process is a by-product of The Atlantic Refining Company's design of catalytic reformer, known throughout the industry as a Catformer.

The Atlantic Refining Company's applications are typical of hundreds of successful jobs these recording and controlling L&N Analyzers are doing, not only in other ammonia synthesis plants, but on widely varied measurements throughout the process industries. For complete product data, write for Folder ND46-91(2). Or, to find how analytical control can benefit specific processes you have in mind, outline your problem for our engineers without obligation. Our address—Leeds & Northrup Co., 4916 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
instruments *automatic controls • furnaces*

GET BALANCED CORROSION-RESISTANCE



Corrosion rate of Causul Metal comp iron and other corrosion-resistin

with money-saving "CAUSUL" METAL VALVES

"Causul" Metal bodies and bonnets are far less expensive than the high alloys — but offer much better resistance to corrosion than cast iron or bronze. Trim is available in Type 316 Stainless Steel or Monel Metal, providing the best corrosion-resistance obtainable in the seats, discs, and stems. With this combination, you get excellent service at minimum cost . . . corrosion-resistant valve service that saves you money.

NOW WITH HEAVIER, STRONGER BODIES!

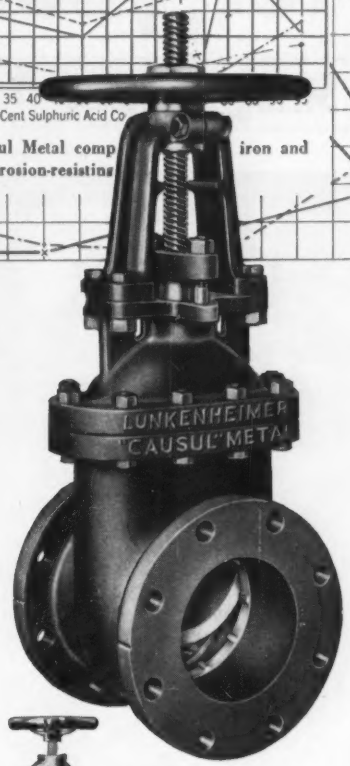
"Causul" Metal Valves are now made with heavier, thicker body walls for extra strength and durability. Castings are poured in a foundry specializing in handling this alloy.

NOW IN A GREATER RANGE OF SIZES!

"Causul" Metal Valves are now made in a complete size range — ½ to 2 inch, screwed ends . . . 1 to 8 inch, flanged ends — with both Monel and Stainless Steel trims.

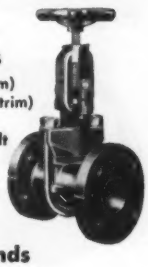
LUNKENHEIMER QUALITY

"CAUSUL" METAL is an exclusive Lunkenheimer development — containing iron, nickel, copper, chromium, and molybdenum. For detailed service recommendations, request a Confidential Service Information Form from your Lunkenheimer Distributor, or write to The Lunkenheimer Company, Box 360, Cincinnati 14, Ohio.





Screwed Ends
Fig. 2008-8 (Monel trim)
Fig. 2008-4 (Stainless trim)
½ to 2 inches



Flanged Ends
Fig. 2009-8 (Monel trim)
Fig. 2009-4 (Stainless trim)
1 to 1½ inches
2 to 3 inches—Two-Bolt Bonnet Design



Flanged Ends
Fig. 2009-8 (Monel trim)
Fig. 2009-4 (Stainless trim)
4 to 8 inches

BRONZE • IRON
STEEL • PVC VALVES

LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

L-355-11

Choose a LINK-BELT Vibrating Screen
for your screening job

Sizing, Scalping, Dewatering, Rinsing . . . at LOW COST



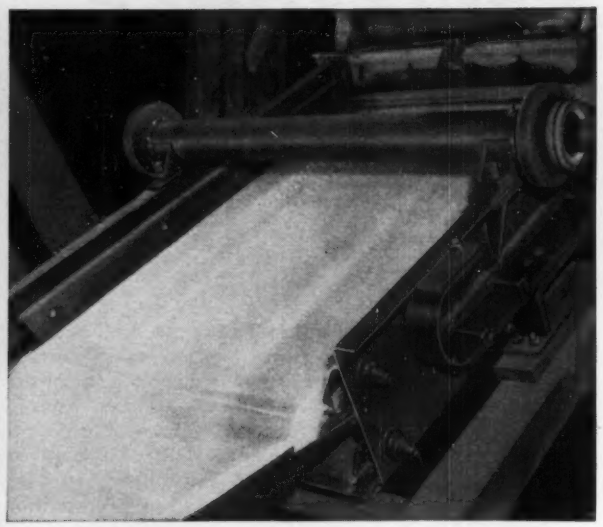
Link-Belt "CA" Vibrating Screen and non-clogging spray nozzles are combined for efficient washing and sizing.

CA

For high-capacity screening of a broad range of materials—Link-Belt "CA" Vibrating Screens are your answer. Concentric Action of vibrator mechanism imparts positive, uniform, circular motion to every square inch of the screening surface. Centrifugally-actuated, unbalanced weights reduce vibration of accelerating and decelerating—are easily adjusted to the amplitude of highest screening efficiency. What's more, lively vibrating action achieves bed stratification *fast*—assures accurate sizing, thorough rinsing, rapid dewatering. Made in a complete range of sizes to suit all plant capacity requirements—single, double or triple decked.



Call your nearest Link-Belt office or write for new Book 2554.



Here fine silica sand is effectively sized by a double-deck Link-Belt "UP" Unbalanced Pulley type vibrating screen.

UP

For economical separation of light to medium weight materials—choose Link-Belt "UP" Vibrating Screens. Positive, high-frequency action over entire area of cloth provides maximum sizing opportunity for every particle. Even on the smallest cloth sizes, blinding is virtually eliminated. And you'll like the lower power and maintenance costs resulting from two-bearing simplicity. "UP" screens are available in open, semi-enclosed, or totally-enclosed types, single or multiple decks in a wide range of sizes.



Get complete information at your nearest Link-Belt office or by writing for Book 2377.

LINK-BELT

VIBRATING SCREENS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,817

FAMOUS LIGHTHOUSES OF AMERICA



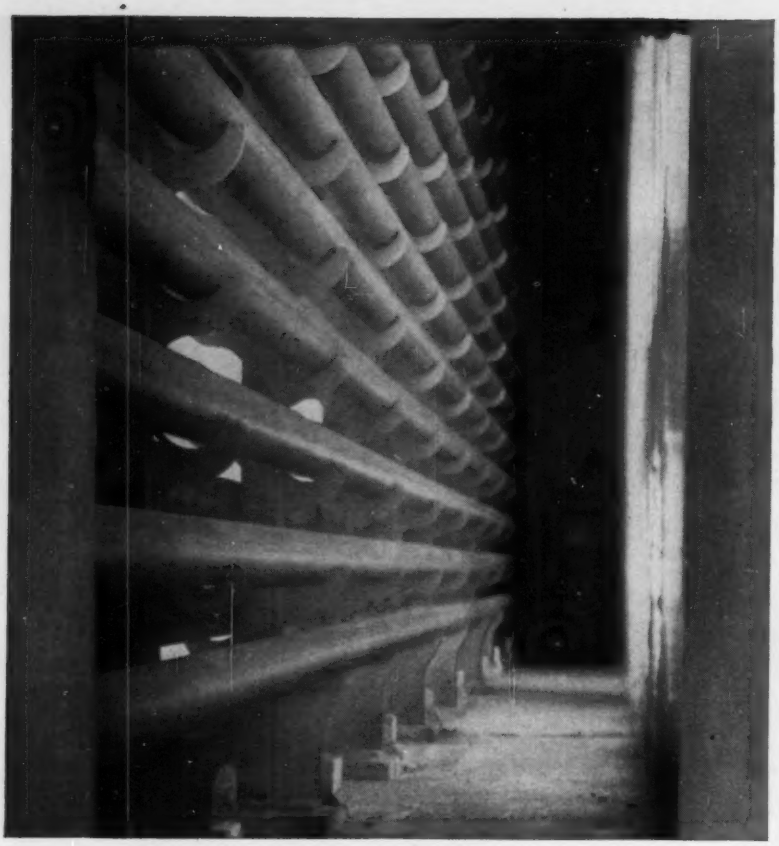
STANNARD ROCK LIGHTHOUSE, Lake Superior, Michigan, is located about 23 miles southeast of Manitou Island. Completed in 1883, the stone tower is built on a base of concrete and stone which stands on solid rock in 11 feet of water. The light, 102 feet above water and visible for 18 miles, protects shipping in a dangerous area on the heavily traveled trade route between Duluth and the lower lakes.

Protection for the quality of your products and the efficiency of your processes is provided by the uniformly high standards of Niagara Alkali products. Depend on the purity and uniformity of Nialk® Liquid Chlorine, Nialk Caustic Potash, Nialk Carbonate of Potash, Nialk Paradichlorobenzene, Nialk Caustic Soda, Nialk TRICHLORethylene, Niagathal® (Tetrachloro Phthalic Anhydride).

NIAGARA ALKALI DIVISION

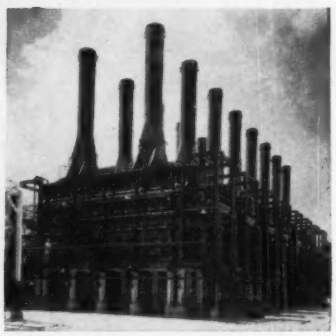
Hooker Electrochemical Company

60 East 42nd Street
New York 17, N. Y.



Incoloy tubes on firing line — In the reaction zone of the Selas furnace, lowest and hottest area, 18 Incoloy tubes carry the stream. Maintenance is very slight.

Battery of 8 Selas cracking furnaces producing ethylene at Gulf Oil's new No. 2 unit from ethane or propane. Independent regulation of banks of burners controls temperature and compensates for wide variations in feed stock composition. Absence of open flame permits compact construction and promotes uniform heating . . . adding to tube life and reducing coking.



Incoloy furnace tubes safeguard ethylene supply

. . . aid production continuity in million pound/day* Gulf *plant

Ethylene is as basic as bread to the petrochemical industry. Continuous, reliable supply is essential.

That's why Gulf Oil Corporation's completion of the No. 2 Unit in its Port Arthur plant is sparking petrochemical development in Texas' Gulf Coast.

New facility assures ethylene at million pound/day level

At the feed end, Gulf's own big nearby refinery is a stable source of ethane and propane. At the distribution end, extensive, highly flexible ethylene storage and pipeline facilities keep product availability at a steady high level.

So does the plant itself. It is designed for maximum continuity of production.

Take the tubes in the cracking furnaces, for example. In the high temperature reaction zone, they are Incoloy* iron-nickel-chromium alloy.

Under prolonged exposure to such conditions, Incoloy alloy is stably austenitic and shows excellent resistance to carburization — providing a factor of safety during decoking if temporary hot spots were to develop.

Speaking of No. 1 Unit, Gulf states: *"These tubes have been in actual cracking service over 9000 hours. Maintenance has been very slight . . . mainly replacing one or two feet at the outlet end of several tubes."* (An easy repair with weldable Incoloy.)

As a result of this experience, Gulf is using 72,000 pounds of Incoloy alloy tubing in the reaction zones of the battery of the 8 new Selas furnaces.

As an extra bonus . . .

Gulf realizes a distinct price advantage in using Incoloy tubing in the relatively inexpensive extruded form.

If the selection of furnace tube materials is your responsibility, you will want to know the advantages of Incoloy. It's easy to get the facts. Just write Inco's Development and Research Div.

*Registered trademark of
The International Nickel Company, Inc.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO
TRADE MARK

Incoloy . . . *for heat-resisting use*

Introducing...

The New BS&B Type 1460 Temperature Controller



Vapor-Tension Sensing System	
Bulb Range	Recommended Working Range
0-100° F.	20-90° F.
40-140° F.	60-130° F.
40-240° F.	90-220° F.
100-350° F.	175-335° F.

FEATURES

- Vapor-Tension Sensing System
- Choice of Temperature Ranges
- Built-In Temperature Indicator
- Simple Adjustment Permits Either 100% Throttling Action—Or "On-Off" Snap Action Within A Wide Limiting Range.
- Parts Interchangeability With BS&B 1440 And 1450 Pilots Reduces Maintenance Cost And Parts Inventory.

Gives Positive Fluid-Flow Control Through Diaphragm Operated Valves, Based On Temperature Variations

The new BS&B Type 1460 Temperature Controller or Pilot is equipped with an external vapor-tension thermal system to actuate the power unit in the pilot.

Except for this actuating mechanism and the temperature indicator which is an integral part of it, the 1460 Controller has all of the excellent features offered in the well-known BS&B Type 1440 Control Pilot—including the ¼" supply medium reducing regulator and two pressure gauges.

This unit is especially suited for translating temperature variations to direct flow-control of fuel, or of heating or cooling medium, through diaphragm operated valves.

Ask your BS&B Representative for more details—or write to . . .

BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-N3

7500 East 12th Street — Kansas City 26, Missouri

do you want low-cost corrosion or contamination

Acetone • Borax • Calcium Carbide • Calcium Carbonate • Calcium Chloride (Flake) • Ethyl Acetate • Ethyl Alcohol • Ethylene Glycol • Glycerine • Insecticide Concentrates • Soap and Soap Lye • Soda Ash • Sodium Bicarbonate • Sodium Silicate •

CF&I LECTRO-CLAD® Nickel Plated Steel Plates will give it to you

Yes, you can get low-cost, yet effective protection against contamination and corrosion with all these chemicals...and many more!

Effective in heavy industrial applications where the corrosion rate does not exceed 0.0015 inches per year, CF&I LECTRO-CLAD Nickel Plated Steel Plates successfully combine the corrosion and contamination resistance of nickel and the economy and strength of carbon steel.

That's because CF&I LECTRO-CLAD is made by the Bart Process, which consists of electrodepositing a heavy layer of 99% pure nickel on a carbon steel plate. This process results in a permanent bond between the nickel and the steel base. The nickel plating is customarily supplied in the 8-10 mil range; however, it can be plated up to 15-20 mils, if specified.

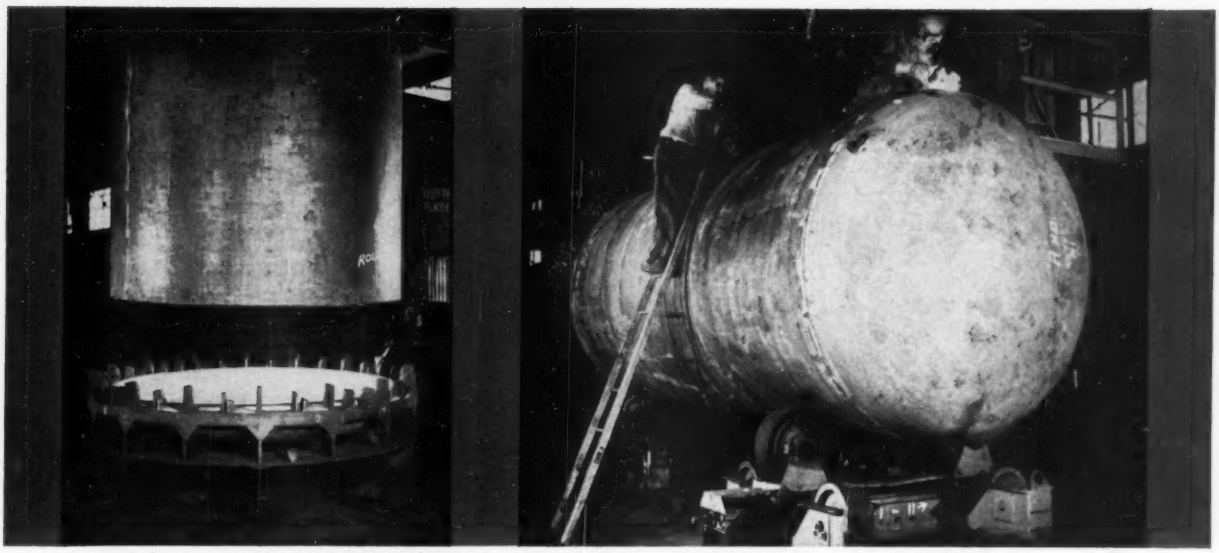
What's more, CF&I LECTRO-CLAD Nickel Plated Steel Plates are easily fabricated without costly special equipment. Just use regular shop equipment and bend it... weld it... roll it—the protective nickel layer will not check, spall or flake!

Ask our nearest sales office for the complete story on economical, effective, easy-to-fabricate CF&I LECTRO-CLAD Nickel Plated Steel Plate* today. Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation, P. O. Box 1951, Wilmington, Delaware.

*CF&I LECTRO-CLAD Nickel Plated Steel Sheets, Pipe, Fittings and Heads are also available.

protection against with these chemicals?

Caustic Soda • Chlorinated Hydrocarbons • Cold Hydrofluoric Acid • Dibutyl Phthalate
Methyl Alcohol • Petroleum Catalysts • Phenol • Potash • Resin Plasticizers • Salt
Sodium Sulphate • Titanium Dioxide • Tricresyl Phosphate



Assembling a tank fabricated from CF&I LECTRO-CLAD Nickel Plated Steel Plates.
The heads have also been nickel electroplated by the Bart Process.

3798

Claymont Steel Products

CF&I

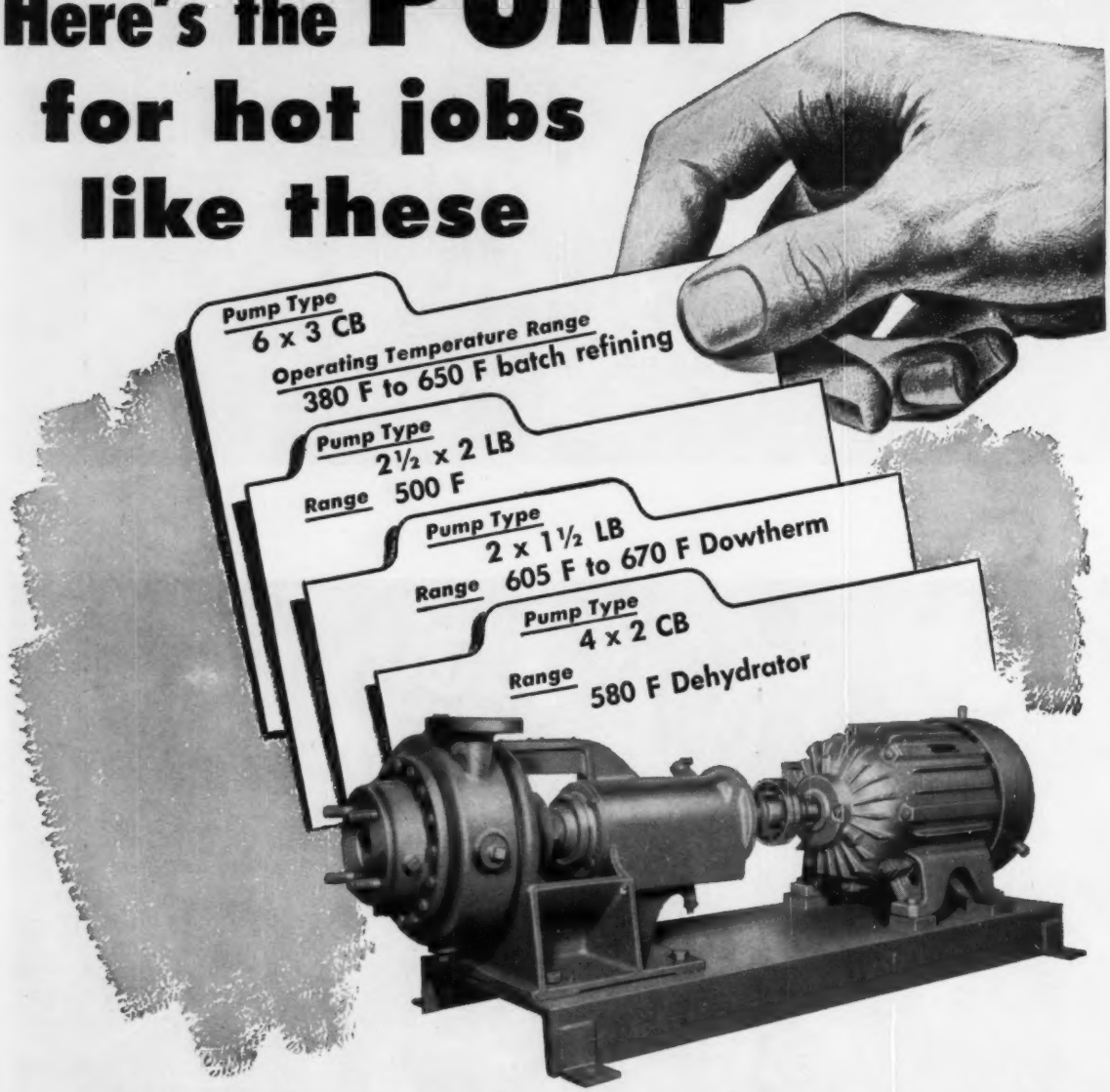
Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation

Abilene • Albuquerque • Amarillo • Atlanta • Billings • Boise • Boston • Buffalo • Butte • Casper • Chicago • Denver • Detroit • El Paso • Ft. Worth • Houston • Lincoln (Neb.) • Los Angeles
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OTHER CLAYMONT PRODUCTS

Stainless-Clad Plates • Manhole Fittings and Covers • Large Diameter Welded Steel Pipe
Flame Cut Steel Plate Shapes • Flanged and Dished Heads • Carbon and Alloy Steel Plates

Here's the PUMP for hot jobs like these



ALLIS-CHALMERS oil-lubricated pumps have excellent service records on many types of high temperature applications like those shown here. This pump is of simple design, yet has all the features required for low cost, low maintenance operation at high temperatures.

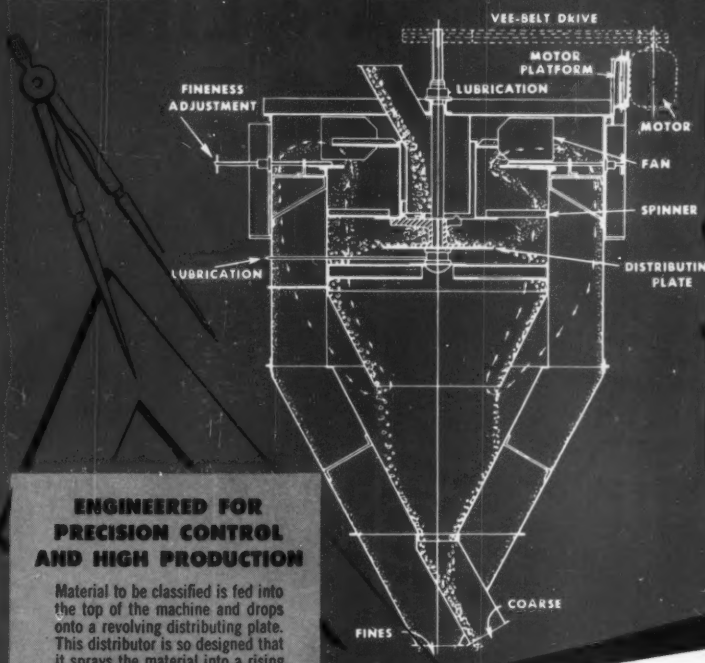
Check the design and construction features that make this possible:

- Built in a wide range of ratings . . . capacities to 3500 gpm, heads to 400 feet.
- Available in wide choice of materials, including iron, bronze, aluminum bronze, stainless steel, high nickel alloys and others.
- Jacketed casing and stuffing box and water-cooled bearings optional.
- Adaptable for packing, mechanical seal or both.
- Simple, accessible design makes maintenance easy.

Allis-Chalmers can supply you with a complete pumping unit — pump, motor and control — all of coordinated design and manufacture and delivered assembled and ready to install. Get complete information from your Allis-Chalmers District Office, or write Allis-Chalmers, Milwaukee 1, Wisconsin, and ask for Bulletin 52B7638.

A-4656

ALLIS-CHALMERS

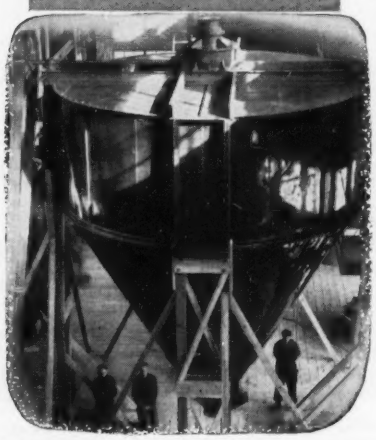


More Accurate Sizing Of Ground And Pulverized Materials!

ENGINEERED FOR PRECISION CONTROL AND HIGH PRODUCTION

Material to be classified is fed into the top of the machine and drops onto a revolving distributing plate. This distributor is so designed that it sprays the material into a rising air current which entirely surrounds the plate. The finer particles are lifted by the air stream and the coarse particles drop down to the reject spout. Passing up through the separating chamber, the dust-laden air is given a whirling motion between Spinner blades and any remaining oversize particles are precipitated. The separator is adjustable to control the fineness of the finished product with unusual accuracy.

WILLIAMS MECHANICAL AIR SEPARATORS For Finenesses From 30 to 325 Mesh



18-Foot Williams RC Separator being tested at plant before shipment.

- Most efficient mechanical air separator ever developed for classifying ground and pulverized materials, or for removing fines from dry ground materials before classifying.
- Product quality is vastly improved and output considerably increased when operated in closed circuit with virtually any type of mill.
- Will handle with equal efficiency a complete range of products—mineral, chemical and vegetable—from the hardest, most dense limestone and ore to the softest, fluffiest starches and flours.
- Permits coarser settings in grinding equipment thus lengthening equipment life by reducing wear on all moving parts. Power consumption is much lower.
- Extra heavy construction. Equipped with anti-friction bearings encased in dust-proof and moisture-proof housings. All casings are of heavy steel plate construction. Operation is dustless and repair cost is practically nil, since there are no fine sieves to wear out and the heavy construction insures long life.

9 Standard sizes, 2½ to 18-foot diameters — Capacities from 500 lbs. to 75 tons hourly

Write For Details And Describe Your Operation

WILLIAMS PATENT CRUSHER & PULVERIZER CO.

2706 NORTH NINTH • ST. LOUIS 6, MO.

WILLIAMS

CRUSHERS GRINDERS SHREDDERS

OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

NEW NATIONAL ANILINE RESEARCH CENTER

Ventilated by "Buffalo" FANS

Handsome and completely functional, the Research-Engineering Center of National Aniline Division of Allied Chemical and Dye Corporation in Buffalo, N. Y., is pictured at right. Shelgren & Whitman, Architects. St. John, Platt & Carlson, Engineers.



COMPACT EXHAUSTERS INSTALLED ON ROOF SAVE FLOOR SPACE

The "Buffalo" Special Chemical Exhaust Fans shown here in the roof installation, are typical of the fine planning and selection of equipment that went into the National Aniline Research-Engineering project. Of all-weather construction, these exhausters have special sturdy cast iron housings which are resistant to moisture and corrosion. These fans have high capacity due to their high efficiency "Buffalo" rotors with backward curved blades.

National Aniline Division is typical of the many leading firms enjoying the finest in plant air-handling service — the famous "Q" Factor* of performance in "Buffalo" Fans. Why not call in your nearby trained "Buffalo" Engineering Representative on your next project — for the best in air results!

Roof installation of "Buffalo" Special Chemical Exhaust Fans at National Aniline. Large number of fans provides flexibility for variations in air handling requirements in many zones.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

501 BROADWAY BUFFALO, N. Y.

PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

New Rokide* Coatings Resist Heat and Abrasion

Rokide spray coatings help solve many high temperature and wear problems

WITH the rapid increase in modern high temperature applications there has been a corresponding increase in demands for resistant materials. Norton ROKIDE spray coatings are meeting such demands with great success. These hard, adherent crystalline refractory oxides offer many important advantages. For example:

They are both thermally and electrically insulating . . . Their hardness, chemical inertness and stability in combustion temperatures provide high resistance to excessive heat, abrasion, erosion and corrosion. Their high melting points and low thermal conductivities reduce the temperatures of the underlying materials and permit higher operating temperatures.

ROKIDE Coatings vs. Stainless Steel

Analyses of Norton ROKIDE spray coatings and of stainless steel reveal interesting comparisons. While less dense than the bare steel, the ROKIDE coatings are very much harder, have considerably higher melting points and are very much lower in thermal conductivity and thermal expansion.

Proof

There are three Norton ROKIDE coatings: ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia. Thoroughly proved in such critical applications as reaction motors, as well as in AEC projects, the value of these coatings to a broad range of more conventional applications is obvious.

Applications

The versatility and adaptability of ROKIDE coatings are evident in the following list of applications, actual and suggested:

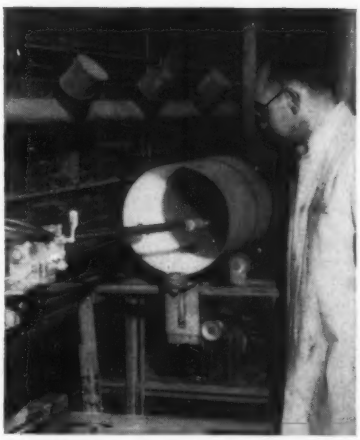
Baffle plates . . . bearing surfaces . . . mechanical seals . . . feed rolls . . . metal treads . . . thermal barriers . . . reflection coatings . . . coatings for exhaust ports, duct linings, ladles and crucibles . . . insulation for copper busbars, circuit breaker components, thermocouple wires and tubes, large and small electronic equipment . . . protection for nozzles, valve plugs, piston heads, pump shafts, gas turbine parts, etc.

Although ROKIDE coatings are most commonly applied to metals they are effective on other materials, such as ceramics and certain plastics. Thicknesses of the coatings generally range from .005″ to .05″.

Other Norton Electric Furnace Materials

are products made of CRYSTOLON* silicon carbide (including ROKIDE "C" coating for graphite parts and CRYSTOLON "N" monolithic shapes), ALUNDUM* fused alumina, MAGNORITE* magnesium oxide, NORBIDE* boron carbide and Fused Stabilized Zirconia. These high-melting materials are also the basic ingredients of the famous Norton Rx's — refractories *engineered and prescribed* for the widest range of uses.

For more detailed information on ROKIDE coatings, use the coupon.



ROKIDE Spray Coatings are applied in a molten state by means of a metalizing type spray gun. The oxide is fed into the gun in rod form at a carefully controlled rate. The coatings can be applied to parts of any size and to all shapes accessible to the spray gun equipment.

NORTON
REFRACTORIES
Engineered... Rx... Prescribed
Making better products... to make your products better

*Trade-Marks

NORTON COMPANY, *Refractories Division*
502 New Bond Street, Worcester 6, Massachusetts

Please send me further facts on ROKIDE coatings.

Name..... *Company*.....

Street.....

City..... *Zone*..... *State*.....

when Flexibility is important in handling dry materials in bulk

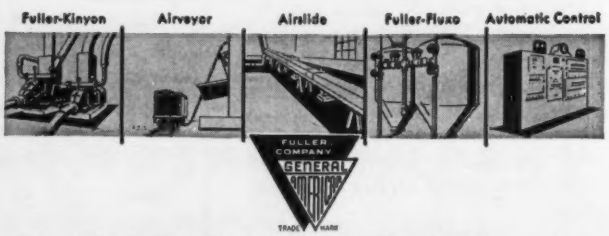
. . . call on Fuller

. . . . pioneers in harnessing AIR

There's always an easier way of doing things, and one of the best examples you'll find anywhere is the ease with which Fuller conveying systems can be adapted to your plant for moving dry bulk materials in any direction, and any reasonable distance you might require, from Receiving to Storage to Process, thence to Shipping.

Materials flow up, down, horizontally, around corners—through walls, over areaways or streets, underground . . . anywhere a pipe line can be installed. The right combination of Fuller-Kinyon, Airveyor, Airslide, and Fuller-Fluxo systems, with a minimum of moving parts, can introduce into your plant operation a new dimension in materials handling.

Your first step toward better plant layout, efficiency, and materials handling economy is to write for Fuller's informative brochure, "How to Pull Dollars Out of Thin Air," filled with pictures of Fuller Equipment on the job. Do it today.



Fuller
. . . . pioneers in harnessing AIR

FULLER COMPANY, 134 Bridge St., Catasauqua, Pa.
GENERAL AMERICAN TRANSPORTATION CORPORATION SUBSIDIARY
Chicago • San Francisco • Los Angeles • Seattle • Birmingham

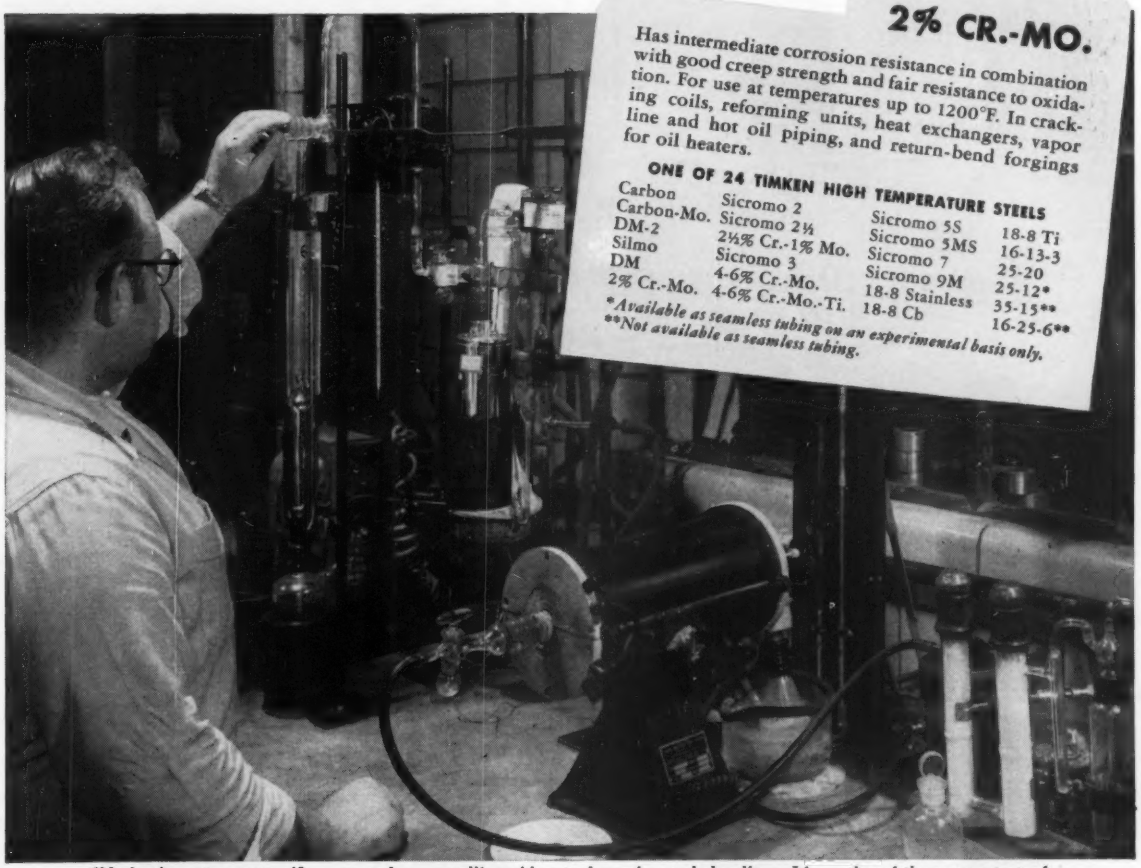
1944
C-117

For the one tube steel to give you the longest tube life per dollar: *Ask the experts!*

CHANCES are that there are several different analyses of tube steel that could solve your particular combination of heat, corrosion, pressure and oxidation problems. But there is only *one* steel that can give you the lowest tube cost per year of required service—the best life/cost ratio.

To find that one steel, *ask the experts!* Ask the Timken Company metallurgists, recognized authorities on high temperature steel tubing. When you consult these experts, you get the benefit of over twenty years' experience with high temperature steels. From the wide range of Timken® fine alloy steels, they can help you select the one that is best for your requirements. And whatever analysis you choose, you'll be assured of uniform high quality. The quality of Timken steels is controlled from melt shop through to the final inspection with the most exacting methods.

Let Timken Company metallurgists help you solve your tubing problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".



2% CR.-MO.

Has intermediate corrosion resistance in combination with good creep strength and fair resistance to oxidation. For use at temperatures up to 1200°F. In cracking coils, reforming units, heat exchangers, vapor line and hot oil piping, and return-bend forgings for oil heaters.

ONE OF 24 TIMKEN HIGH TEMPERATURE STEELS

Carbon	Sicromo 2	Sicromo 5S	18-8 Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-20
Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

**Available as seamless tubing on an experimental basis only.*
***Not available as seamless tubing.*

Chlorination apparatus purifies extracted non-metallic residues to determine steel cleanliness. It's another of the many aspects of high temperature steel research in constant progress at the Timken Company.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



TIMKEN
Fine Alloy
STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

STAYNEW FILTERS

Dollinger makes ALL TYPES of filters as shown on this page, plus special filters for unusual filtration problems. New users of one specific type of Staynew filters often find a second Dollinger filter performs a great, added service in other processes or operations. Perhaps we can serve major or other filtration needs of your plant.

LIQUID FILTERS



Model HE (Sump) Liquid Filter Bulletin 330

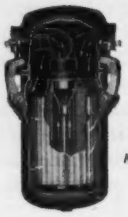


Model ELS (Pressure) Liquid Filter Bulletin 300

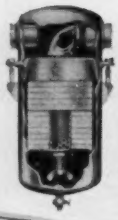
PIPE LINE FILTERS



Model CPH Pipe Line Filter Bulletin 200



Model CVH (Vacuum) Pipe Line Filter Bulletin 200



Model AAPHS (Absorption) Pipe Line Filter Bulletin 200



Model HPH and AHPH (High Pressure) Pipe Line Filter Bulletin 200

all types of FILTERS for every INDUSTRIAL NEED

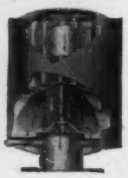
AIR INTAKE FILTERS



Model IDR (Ground Level) Air Intake Filter Bulletin 100



Model DS (Silencer) Air Intake Filter Bulletin 100



Model D (Outdoor) Air Intake Filter Bulletin 100



Model C (Indoor) Air Intake Filter Bulletin 100

VENTILATION FILTERS



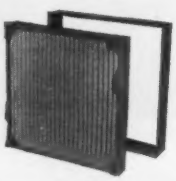
Electro-Staynew Mist Collector Bulletin 420



Electro-Staynew Precipitator Bulletin 400



Automatic Ventilation Filter Bulletin 500



Dry and Viscous Panel Ventilation Filters Bulletin 600 and 700

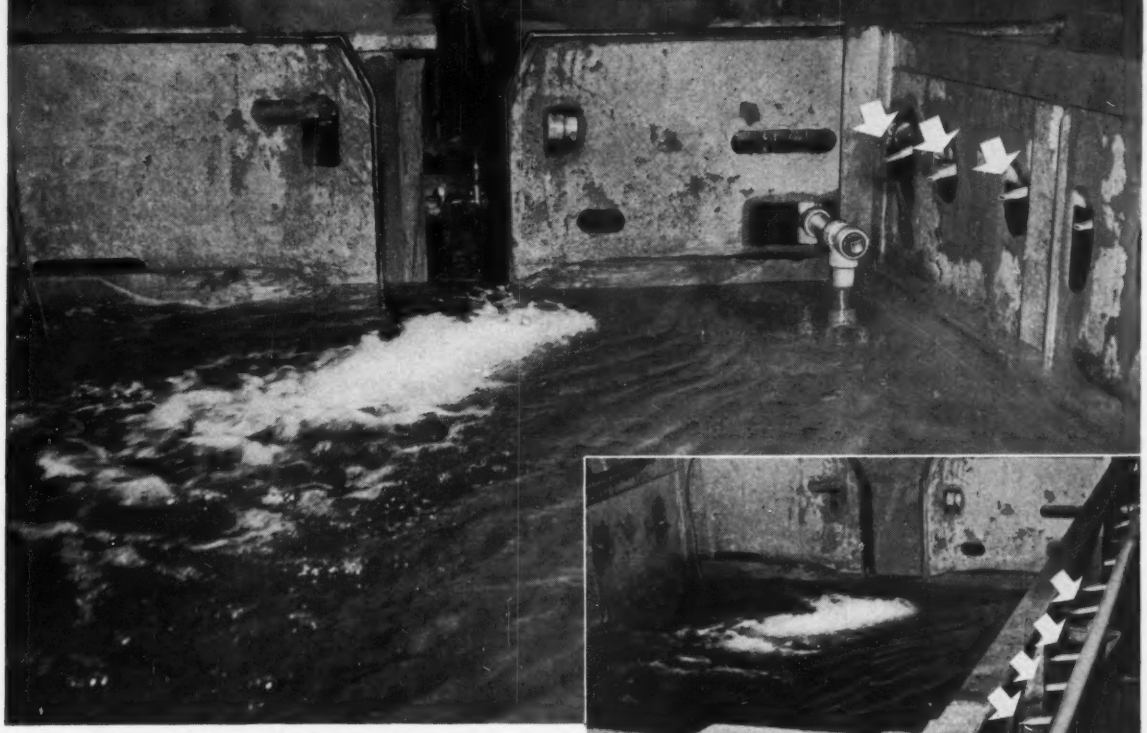
DOLLINGER REG. PROTECTOMOTOR U.S. PAT. OFF. STAYNEW FILTERS

DOLLINGER CORPORATION CENTRE PK. ROCHESTER 1, N.Y.

Write, using Bulletin Numbers, for complete information on any of the Staynew filters illustrated. Consult Dollinger engineers on any special filtration problems—no obligation. Dept. 4 Centre Park, Rochester.

LIQUID FILTERS, PIPELINE FILTERS, INTAKE FILTERS, HYDRAULIC FILTERS, ELECTROSTATIC FILTERS, DRY PANEL FILTERS, VISCOUS PANEL FILTERS, LOW PRESSURE FILTERS, HIGH PRESSURE FILTERS, AUTOMATIC VENTILATION FILTERS, NATURAL GAS FILTERS, SPECIAL DESIGN FILTERS, SILENCER FILTERS

FOR AN ACID CONDITION, THERE'S NOTHING LIKE U. S. Uscolite Plastic Pipe



Uscolite nozzles (arrows) are used to wash acid off steel stock.

Close-up of Uscolite pipe which carries water to the Uscolite nozzles (arrows). The tanks are lined with U. S. corrosion-resistant Permobond rubber lining.

A large manufacturer of wire and cable in New England is one of the many who find U. S. Uscolite® Pipe immune to acid conditions. "Uscolite is the most effective material we have found for this service," says the management of the plant. Uscolite pipe and Uscolite nozzles are used to wash off acid after cable and wire are immersed in pickling baths —for two big reasons:

(1) Uscolite is immune to corrosion from the splash-drip and spray off the steel stock as it comes from the pickling bath.

(2) Uscolite nozzles not only last far, far longer than metal nozzles, but they also require no clean-out.

Uscolite piping is a product of United States Rubber Company. Both its interior *and* exterior are resistant to acids, salts, alkalies, gases. Despite Uscolite's great impact strength, it is surprisingly light in weight. You can also order it in pipe fittings and valves.

Whether ordering completely new piping, or getting replacements, specify U. S. Uscolite. Get in touch with any of the 27 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y.

Uscolite pipe and fittings are made in the broadest and largest line of stock sizes on the market. Sizes follow:

● Molded fittings in ½" through 4" I.P.S. ● Molded flanges ½" to 6" I.P.S. ● ½" to 3" Uscolite diaphragm valve (Hills-McCanna). ● Pipe in standard wall dimensions and extra heavy wall dimensions in ½" through 6" pipe sizes.

Mechanical Goods Division

United States Rubber

Here's how you can help make stainless plate stocks go a LONG way...

Whenever demand outdistances supply you have problems. But any problem can be solved when all hands cooperate. If you keep in mind these "rules of the road" you will be able to add extra mileage to the supply . . .

1. If you have a D.O. rating, give it to your supplier—it helps him get the necessary nickel, and protects your position on his schedule.
2. If you are going to cut plate into smaller pieces, give your supplier the option of furnishing small pieces.
3. Plan ahead as much as possible, so your supplier has a reasonable chance to meet your delivery requirements.
4. If an alternate analysis or a slight variation in gage is acceptable, let your supplier know.
5. Buy "cut-to-shape" pieces and reduce your time and costs of handling scrap.
6. Clean out your stainless scrap so that it can get back into production.
7. Order only what you need in stainless plate—to exact size.

Put these simple rules to work . . . it will help you, and all of us, stretch the supply to the limit.

Stainless Steels Exclusively

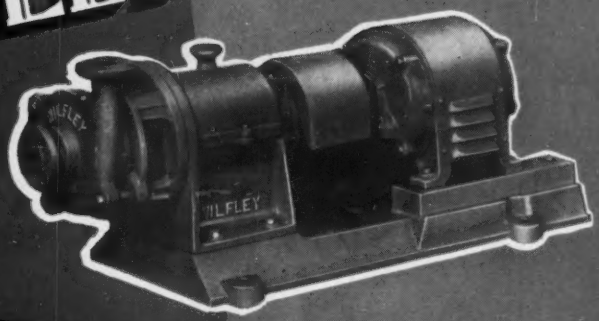
G. O. CARLSON, INC.

Plate • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

From WILFLEY ACID PUMPS



. . . to GLASS FABRIC



Glass fabric for fishing rods is rolled around a tapered steel form and heat-bonded. The form is then removed, creating the tubular glass rod blank.

Fishing rods are one of many glass products that originate in chemical plants where the basic ingredients are handled by Wilfley Acid Pumps. These highly efficient pumps operate without attention, delivering trouble-free performance on 'round-the-clock schedules. Let Wilfley reduce your pumping costs and increase production. Available with pumping parts of the machinable alloys as well as plastic to meet all requirements. Individual engineering on every application. Write, wire or phone for complete details.

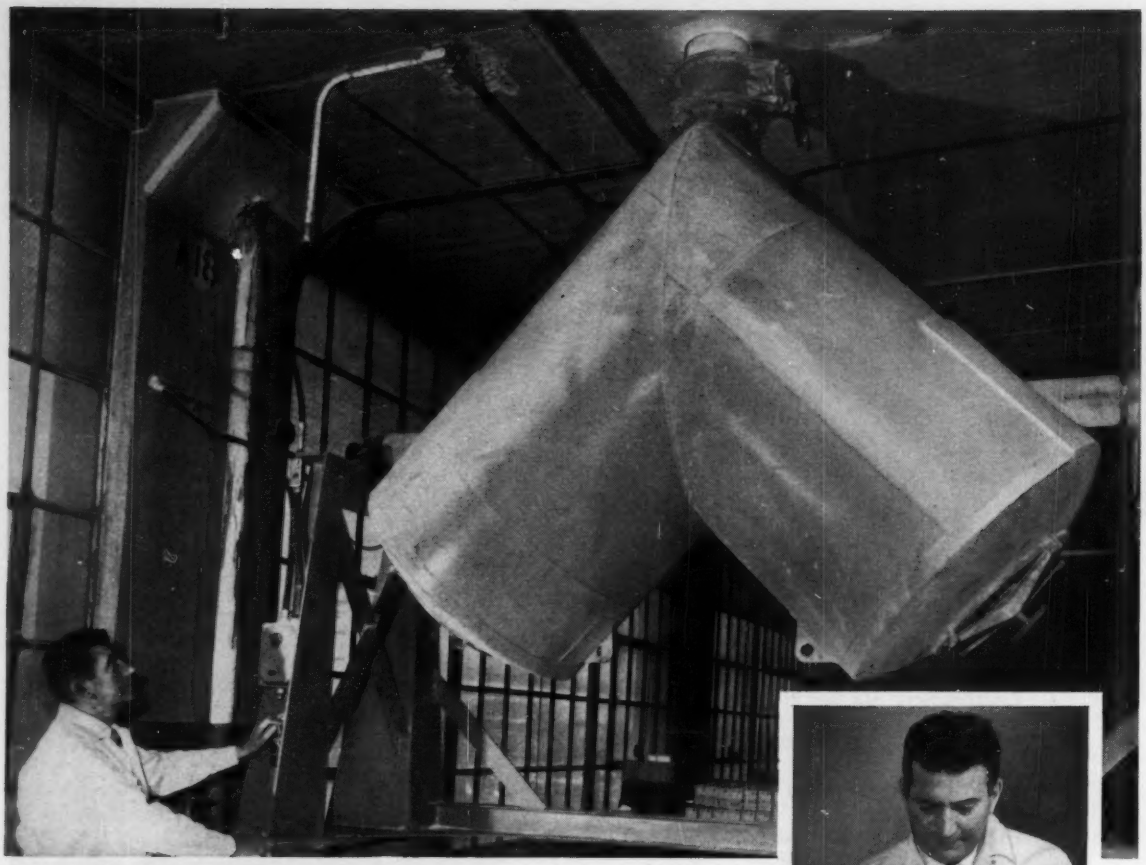


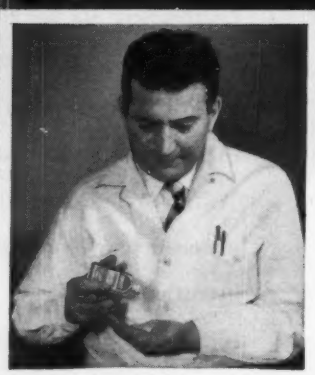
. . . to FISHING RODS

A. R. WILFLEY and SONS, INC.

DENVER, COLORADO, U.S.A.

New York Office: 1775 Broadway, New York City





This giant p-k twin shell blender has already blended millions of pounds of Durkee seasoning salts, loading efficiently from the floor above and discharging to the floor below. Blending, cleaning and maintenance time have been so reduced that this twin shell paid for itself in only a few months. Stewart Woodruff (right), head of Durkee's research lab, conducted the extensive tests which led to the selection of the twin-shell blender.

"Blends perfectly; virtually self-cleaning":

DURKEE SELECTS p-k BLENDER AFTER LABORATORY "PRE-TEST"

We're at Durkee Famous Foods, in Elmhurst, N. Y. . . . and you're looking at a 1000-lb. **p-k** twin shell blender which was so thoroughly pre-tested, success was assured even before it was installed!

Extra-effective blending is a must at Durkee, because physical segregation between various ingredients in Durkee's onion salt and garlic salt is a problem. That's why, when it comes to choosing a blender, there could be no guesswork.

The twin shell, along with other blenders, was put under careful scrutiny. A 4-quart **p-k** laboratory model underwent a series of tests in Durkee research labs. There, in much less than half the time needed to produce a hand sample of almost perfect theoretical value, the **p-k** twin shell, in test after test, produced identical samples. Because blending results obtained with twin shell lab models scale up accurately to production sizes, Durkee research men knew the twin shell was the "just right" blender for the job—*before* it was purchased!

To find out how you, too, can "pre-test" a **p-k** twin shell blender in your plant, lab or mill, write us today. Ask, too, for your copy of **p-k** Catalog 13. It is free for the asking, of course. **The Patterson-Kelley Co., Inc., 130 Lackawanna Avenue, East Stroudsburg, Penna.**

PATTERSON KELLEY

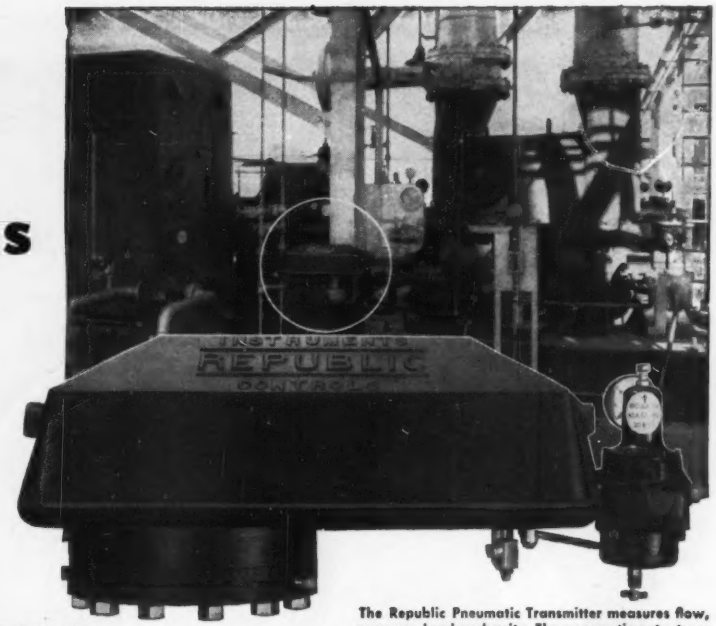
2565

Offices: 101 Park Avenue, New York 17 • Railway Exchange Building, Chicago 4 • 1700 Walnut Street, Philadelphia 3 • 96-A Huntington Avenue, Boston 16 and other principal cities

Republic

PNEUMATIC TRANSMITTERS

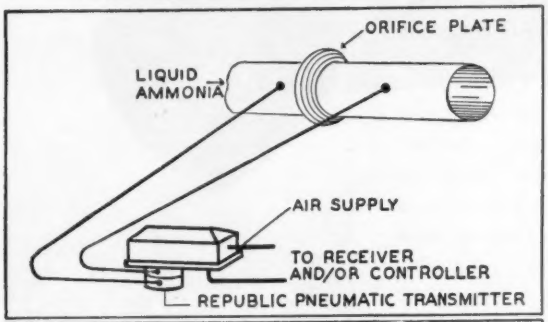
. . . Your Best Solution to Tough Metering Problems Like These:



The Republic Pneumatic Transmitter measures flow, pressure, level or density. The pneumatic output can be used to operate reading instruments and as the measuring impulse to an automatic controller.

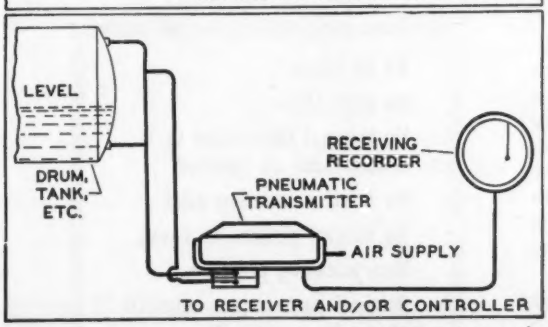
LOW DIFFERENTIAL FLOW MEASUREMENT

When pressure drops in flow lines must be kept small—as in the discharge of blowers—low range Republic Transmitters offer the most practical answer to flow measurement. For *only* with Republic Transmitters can you get differential ranges as low as 0-0.6-in. H_2O at static pressures to 15 psi and 0-2.5-in. H_2O at pressures to 1000 psi. This low range feature permits the use of devices producing a minimum differential; accurate force-balance measurement and control is possible with back-pressure on blowers, for example, held to a negligible figure.



METERING VAPOROUS LIQUIDS

Repulic's low ranges provide the key to successful measurement of easily vaporized liquids, too. Take the flow of liquid ammonia through an orifice as an example. By using an orifice producing a small differential drop, you avoid flashing the liquid into gas and getting an inaccurate measurement. And since the Republic Transmitter is a force-balance instrument, there are no problems of liquid seals, purging or overrange blowing the sealing liquid into flow lines.

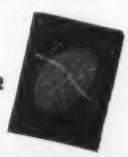


LIQUID LEVEL MEASUREMENTS UNDER PRESSURE

This job requires an instrument with a narrow range span and considerable range suppression. High pressure, low range Republic Transmitters are available for just this kind of measurement. For accuracy and close control, range suppressions up to four times the range span are possible i.e., a Republic Transmitter with a 0-100-in. H_2O range can be suppressed to operate between any 20-in. H_2O span within the full 100-in. range.

● ***IF YOU HAVE A PROBLEM***
involving the measurement of
FLOW, PRESSURE, LEVEL OR DENSITY
with pneumatic transmitters . . .

Write for Data Book 1004. It describes and illustrates 22 different Republic Transmitter models, gives hook-ups, ranges, performance data. Write for a free copy.



REPUBLIC FLOW METERS CO. ● 2240 Diversey Parkway • Chicago 47, Illinois

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
395 WILSON, SO. NORWALK, CONN.

ADSORPTION IS A BASIC CHEMICAL ENGINEERING PROCESS

DARCO

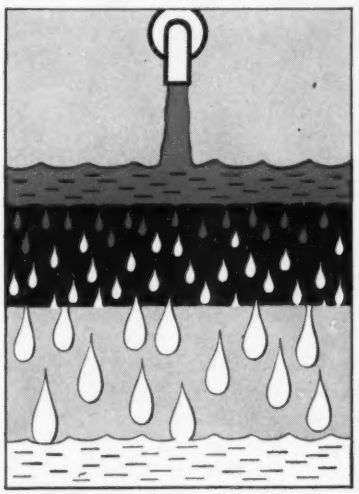
REG. U. S. PAT. OFF.

DARCO Digest

CHEMICALS DIVISION, ATLAS POWDER COMPANY, WILMINGTON 99, DELAWARE • Atlas Powder Company, Canada, Ltd., Brantford, Ontario, Canada

Using Adsorption to Purify Materials Recovered by Crystallization

The recovery of crystalline products from solution is a technique applied to a wide range of materials, such as sugar, monosodium glutamate, dye intermediates, caffeine, fumaric acid and many others, which are refined in processes where the mother liquor is re-cycled. The liquor must be cleaned of impurities which tend to build up, or the whole system will become inoperative; crystals of inferior color, shape, clarity and odor will be obtained, and the yield of crystals per cycle will diminish.



To offset this, a number of purification processes are available, such as solvent extraction, precipitation, distillation, or adsorption (including ion exchange). The trick with mother liquors is not to allow impurities to build up from cycle to cycle. Since activated carbon is most effective for removing impurities present in low concentration, it is thus ideal for mother liquor treatment.

Our long experience in applying Darco activated carbon to many purification problems stands ready to serve you.

High Bulk Density of Darco Cuts Filtration Costs

Darco is a relatively dense activated carbon, of high adsorptive capacity. This high density makes for greater economy at the filter press . . . for several reasons.

Darco gives longer filter cycles. A filter of given cubic capacity will hold nearly twice as much Darco as lighter carbons.

For comparable dosage in pounds of carbon per gallon of liquor, Darco will give considerably longer filter operation between clean-outs . . . and corresponding savings in labor and production time. The saving may amount to several cents per pound of carbon. Figure it out yourself.

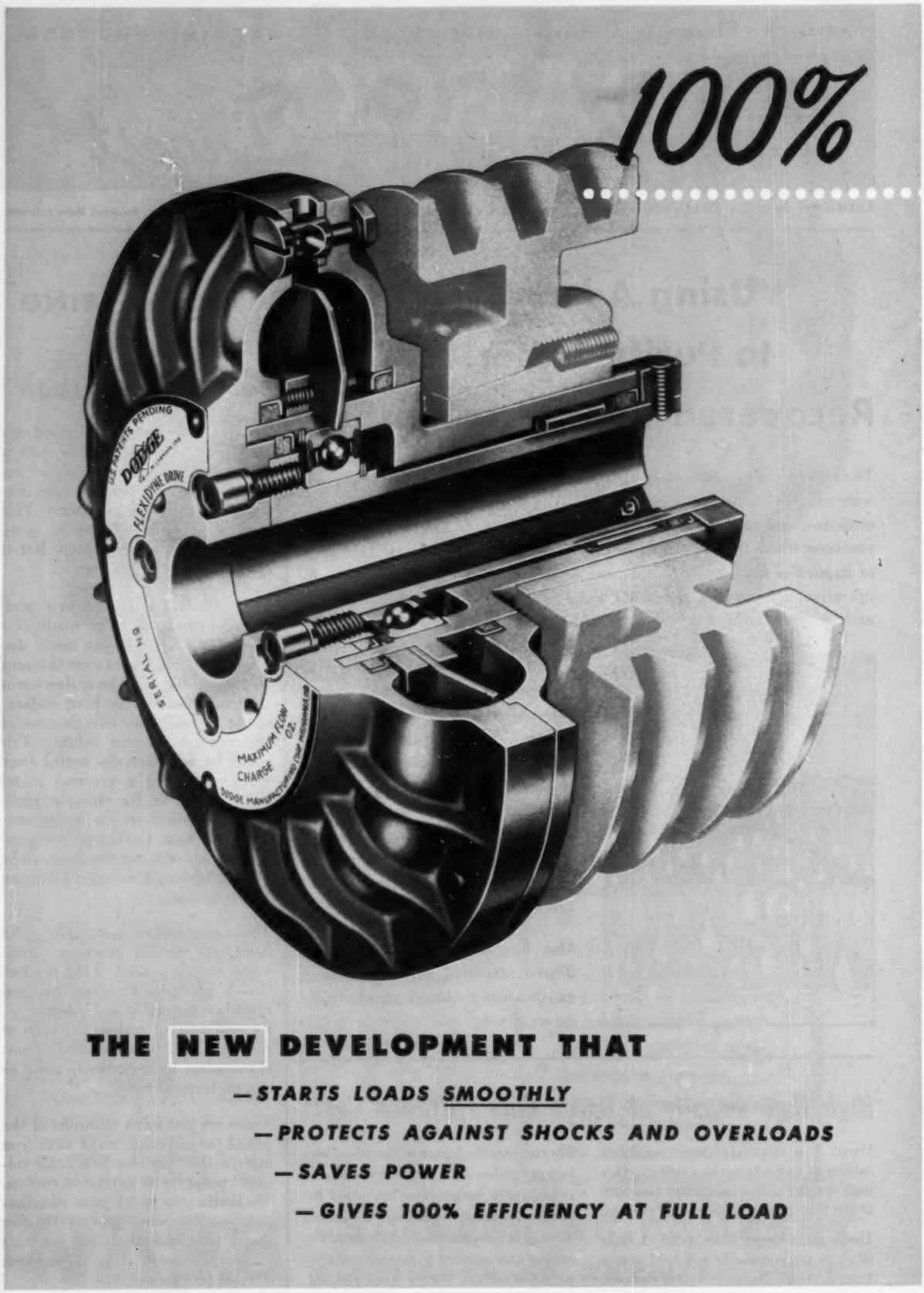
IMAGINEERING *with activated carbon*

The unique fact about activated carbon is that it is a material with a large area inside of a pore structure. 50 to 100 acres of pore area are contained in a pound of carbon. This tremendous area, of course, is an excellent adsorptive surface. But it may have other uses, too.

For instance, a large area in a small volume sounds like a fine quality for a catalyst. Suppose you could disperse a catalytic agent over this area . . . spreading out the active agent over millions of tiny pore surfaces might increase the effectiveness of the catalyst per unit volume. This could be an especially useful trick when you need a precious metal catalyst . . . as, for example, platinum or palladium for hydrogenation processes. Carbon so prepared is an article of commerce, and can be obtained from producers of platinum and palladium.

The carbon surface is catalytic all by itself, for certain reactions. Activated carbon is used in the production of phosgene by direct reaction of carbon monoxide and chlorine . . . for synthesizing various chlorides of sulfur . . . and for making numerous chlorinated hydrocarbons, such as carbon tetrachloride.

These are just a few examples of the out-of-the-ordinary ways that you can use the "big idea in a small volume" property of activated carbon. We invite you to let your imagination run free when you're thinking about problems that can use this property, in your lab or in your production processes.



THE NEW DEVELOPMENT THAT

—STARTS LOADS SMOOTHLY

—PROTECTS AGAINST SHOCKS AND OVERLOADS

—SAVES POWER

—GIVES 100% EFFICIENCY AT FULL LOAD

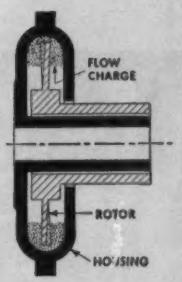
Efficiency at Full Load!

FLEXIDYNE

THE DRY FLUID DRIVE

Field experience proves that the new principle employed in Flexidyne provides a better way to handle difficult drive problems.

The "dry fluid" in Flexidyne is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing, which is keyed to the motor shaft. When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, wedging it between the housing and the rotor which transmits power to the load.



After a momentary slip between housing and rotor the two become locked together and achieve full load speed without slip and at 100% efficiency during the running cycle.

Flexidyne is easy to select *off the shelf*. Each size has a standard horsepower rating, yet the flow charge can be varied quickly to give you tailor-made torque to suit the job.

Write for bulletin A-640, or call your Dodge Distributor now about Flexidyne Drives and Flexidyne Couplings.

DODGE MANUFACTURING CORPORATION
200 Union Street, Mishawaka, Indiana

FLEXIDYNE AT WORK TURNS IN GREAT PERFORMANCE RECORD!

Flexidyne Drives and Couplings are now being delivered from stock. Already reports like these are coming in about Flexidyne performance in many tough assignments.

RAILROAD CAR PULLERS
"Starts fine... summer or winter!"

CONVEYORS
"We start under full load now!"

COTTON CARDS
"Finally... the soft start!"

TRAVELING CRANES
"Spots our loads... and how!"

PUMPS
"Now we are using smaller motors, too!"

VENTILATING FANS
"Takes off smooth as silk!"

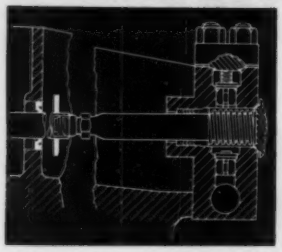
...AND OTHER HEAVY INERTIA LOADS
"Wonderful performance!"

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone book, or write us.

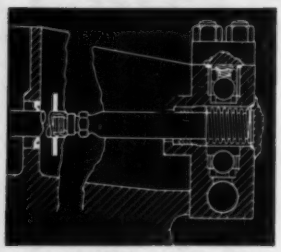


DODGE
of Mishawaka, Ind.

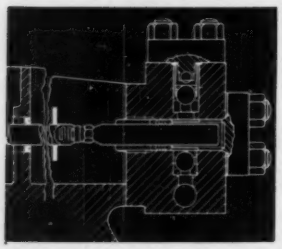
Name Your Triplex Pumping Problem **GAULIN** has a Maintenance-Saving Answer



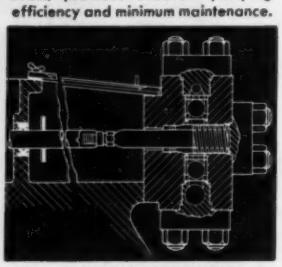
FOR FLUID, non abrasive products the Gaulin Spring-Loaded Poppet Valve provides low initial cost and low maintenance.



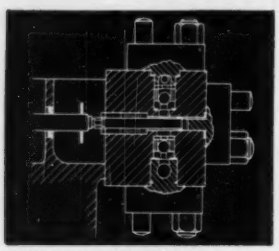
FOR VISCOUS, heavy-bodied products, the Gaulin Ball Valve (spring-loaded packing, inserted seats) provides excellent pumping efficiency and minimum maintenance.



FOR SLIGHTLY ABRASIVE, viscous products, the Gaulin Ball Valve (adjusting screw packing, inserted seats) keeps maintenance costs down.



FOR SLIGHTLY ABRASIVE, viscous products, where maintenance must be accomplished in minutes, the Gaulin Ball Valve with removable seats (spring-loaded packing) cuts maintenance time to the bone.



FOR VERY ABRASIVE products, the Gaulin Ball Valve (with adjusting screw packing, removable seats) provides the ultimate in low cost maintenance.

Name Your Capacity

There's a Gaulin to handle your capacity from 50 GPH to 5,000 GPH.

Name Your Pressure

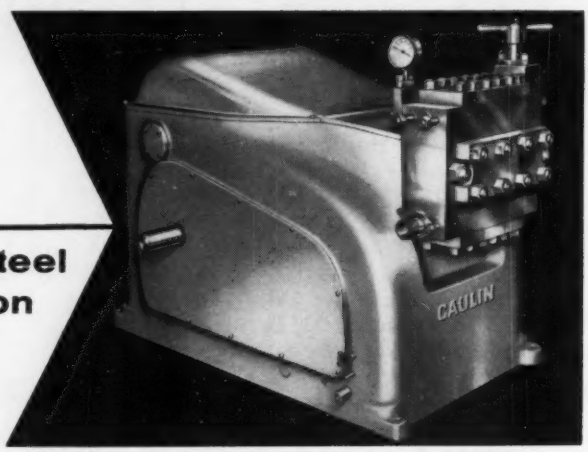
Gaulins are designed for 3 basic pressure ranges — up to 3,000, 5,000 and 8,000 psi.

Name Your Product

Only Gaulin designs a specific cylinder to handle every product efficiently, economically. Note some of our designs shown and described at the left.

Horizontal Design

Stainless Steel Construction



For Transfer, Metering, Spray Drying

A Gaulin Triplex Pump is a rugged, heavy-duty machine built to minimize operating, inspection, and maintenance costs. Compact. Simple. Dependable. Its horizontal design positively separates your product from the crankcase . . . and makes every part easy to get at.

Just lift two plates and a Gaulin drive and plunger assembly is convenient for inspection or repair.

A Gaulin Cylinder may be disassembled in a matter of minutes, cuts maintenance time to the bone!

Vibrationless. A Gaulin is practically free of vibration.

Corrosion-proof. All product contacting parts are stainless steel. Ceramic plungers or other materials are available for special applications.

Rugged Dependability. Thousands of installations with well-known companies prove a Gaulin provides unusually long service at minimum cost.

Write for new bulletin. Ask for No. P-55.

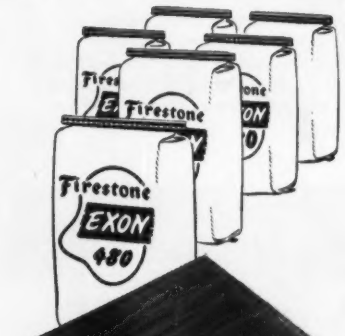
MG/156-1

Gaulin

Manton-Gaulin

Manufacturing Company Inc., 55 Garden St., Everett 49, Mass.

EXON: each resin engineered for a specific problem



EXON 480

specifically for

records



High tonal quality and exceptional resistance to breakage are assured when you make "biscuits" with EXON 480.

This Firestone resin provides unique production advantages in the blending, fusing, preforming and molding processes. Its higher bulking density speeds up banbury output as much as 25%.

EXON 480 offers high thermoplasticity, good heat and light stability, and is entirely compatible with the vinyl plasticizers, stabilizers and pigments record-makers most often use.

Continuing Firestone research aids industry by creating such specific resins for specific needs. Whatever your problem, the answer may well lie in this ever-growing line of EXON resins.

Firestone

EXON®

For complete information or technical service on any EXON *resin, call or write today:*

CHEMICAL SALES DIVISION

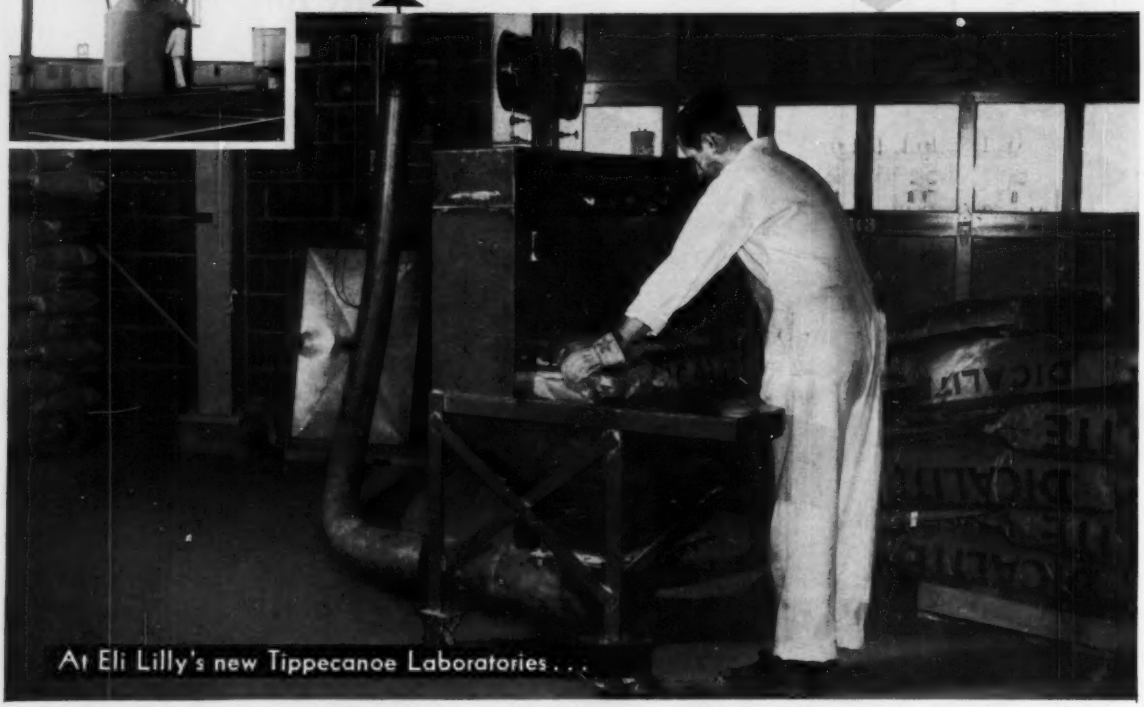
FIRESTONE PLASTICS COMPANY, POTTSTOWN, PA., DEPT. 628E

A DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY



Material is sucked from the intake hopper a distance of 140 feet to this roof-top Airstream receiver. Here it is collected and gravity-fed into slurry tanks below.

A unique Airstream intake hopper, designed specially for the Lilly installation, slits the bags and introduces the material into the conveying line. A hood above the hopper prevents spread of dust. As an added convenience it may be rolled into a nearby boxcar for direct unloading.



At Eli Lilly's new Tippecanoe Laboratories . . .

another "problem" material conveyed economically by Airstream

Dry materials become "problem" materials when they require special handling precautions. For example, some chemicals must be kept contamination-free; all foods must remain pure; fragile materials must not be powdered or crushed. Hundreds of these "problems" have been solved by Dracco—with the materials handled swiftly and economically by Dracco Airstream Conveyors.

An example of a Dracco-engineered solution for handling such materials is the Airstream system used by Eli Lilly & Company at the ultra-modern Tippecanoe Laboratories in Lafayette, Indiana. Here, a friable filter aid, purchased in bags, is delivered directly to process at 7½ tons per hour from the warehouse.

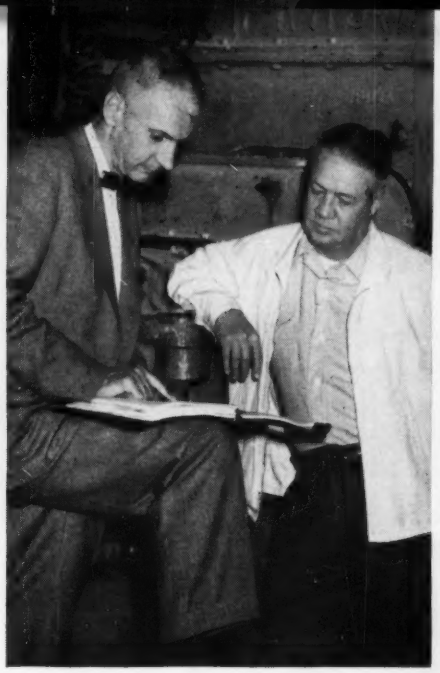
A special Airstream technique protects the material against breakage which would destroy its effectiveness. The self-cleaning action of the system eliminates maintenance problems and permits instant change-over to other materials without intermixing. Fast, one-man operation cuts costs, absence of dust avoids housekeeping and contamination problems.

If you have a problem in handling dry materials, investigate the advantages of Airstream conveying with its many cost-saving features. Explain your situation to Dracco—we'll do the rest. Write or call today.

DRACCO CORPORATION
4040 East 116th Street • Cleveland 5, Ohio

FREE! THE DRACCO ENGINEER. Describes Dracco solutions to many bulk materials handling and dust control problems . . . includes tips on improving plant efficiency . . . published quarterly. Get on the mailing list. Write on your letterhead today!

DRACCO *Performance Proved*
Airstream **CONVEYORS • DUST CONTROL EQUIPMENT**



A. D. Schnurr (right), Kalo Brick & Tile Company president and Standard Oil lubrication specialist Roland C. Bleimehl discuss plant lubrication requirements. Providing technical service on lubrication is something for which "Rollie" Bleimehl is well qualified. Rollie is a mechanical engineer with a degree from Iowa State College and a graduate of the Standard Oil Sales Engineering School. He's been an industrial lubrication specialist for 10 years with the Standard Oil Company. Customers find his experience and training pay off *for them.*



Large open gear, such as this one in Kalo Brick & Tile plant, suffered excessive gear tooth wear until their Standard Oil man suggested switch to CALUMET Viscous. New lubricant eliminated throw off, reduced gear replacement and maintenance.

CALUMET Viscous Lubricant solves gear lubrication problem for Kalo Brick & Tile Company

Long-time Standard customer receives another demonstration of effectiveness of Standard Oil Products and technical service.

The Kalo Brick & Tile Company, Fort Dodge, Iowa was experiencing trouble with the lubrication of open gears. The lubricant used lacked adhesive qualities and was being thrown off resulting in excessive gear tooth wear. In addition, the lubricant had to be heated before application.

As they had done in so many cases during sixty-five years as a Standard Oil customer, Kalo management called in a Standard industrial lubrication specialist. Inspection and recommendation by the Standard man resulted in a switch to CALUMET Viscous Lubricant for open gears. Kalo Brick & Tile Company got these results: gears received an effective shield that did not throw off, life of gears was lengthened and lubrication maintenance and attention greatly reduced, no preheating of CALUMET Viscous Lubricant was required so this messy job and the preheating equipment were eliminated.

No matter what the problem, chances are Standard Oil lubricants and technical service can help you solve it. Try them. Call your nearby Standard Oil lubrication specialist in any of the 15 Midwest and Rocky Mountain states. Or write Standard Oil Company, 910 South Michigan Avenue, Chicago 80, Illinois.



Kalo Brick & Tile Company plant, Fort Dodge, Iowa found solution to gear lubrication problem by using CALUMET Viscous Lubricant.

Quick facts about

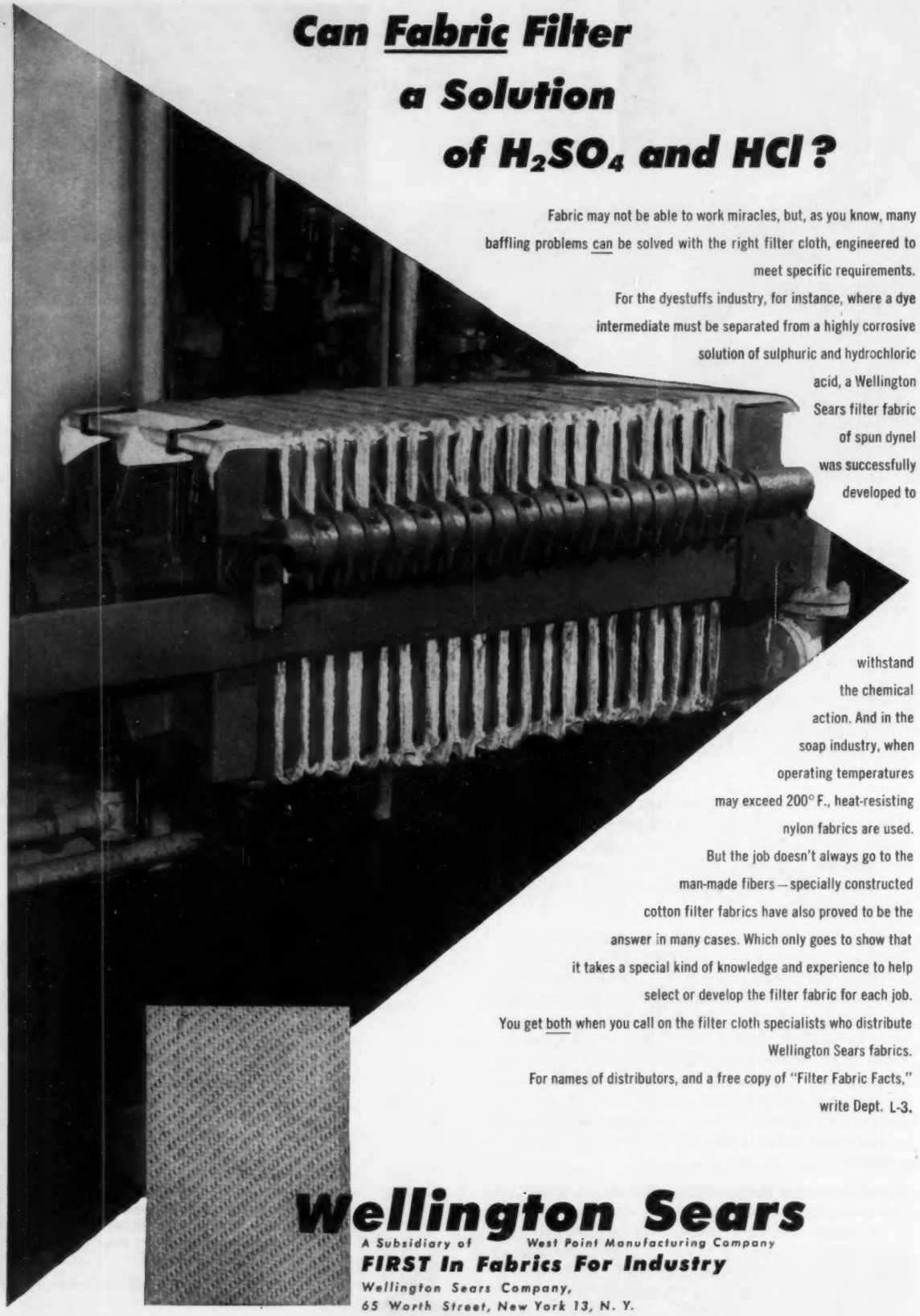
CALUMET Viscous Lubricant

- **Not a residual product but a true grease carefully manufactured from selected soaps, oils and additives.**
- **Good wetting ability. Gives lubricant superior adhesiveness, makes it resistant to washing.**
- **Has very high load-carrying capacity. CALUMET Viscous grease formula is especially designed to provide effective shield under heavy load.**
- **Resistance to heat. Since it is a true grease compound, CALUMET Viscous has extreme stability, does not thin out under high heat.**

STANDARD

STANDARD OIL COMPANY
(Indiana)

Can Fabric Filter a Solution of H_2SO_4 and HCl?



Fabric may not be able to work miracles, but, as you know, many baffling problems can be solved with the right filter cloth, engineered to meet specific requirements.

For the dyestuffs industry, for instance, where a dye intermediate must be separated from a highly corrosive solution of sulphuric and hydrochloric acid, a Wellington Sears filter fabric of spun dynel was successfully developed to withstand the chemical action. And in the soap industry, when operating temperatures may exceed 200° F., heat-resisting nylon fabrics are used.

But the job doesn't always go to the man-made fibers—specially constructed cotton filter fabrics have also proved to be the answer in many cases. Which only goes to show that it takes a special kind of knowledge and experience to help select or develop the filter fabric for each job.

You get both when you call on the filter cloth specialists who distribute Wellington Sears fabrics.

For names of distributors, and a free copy of "Filter Fabric Facts," write Dept. L-3.

Wellington Sears

A Subsidiary of West Point Manufacturing Company

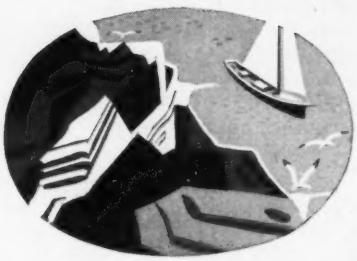
FIRST In Fabrics For Industry

Wellington Sears Company,
65 Worth Street, New York 13, N. Y.

Offices in: Atlanta • Boston • Chicago • Dallas • Detroit • Los Angeles • Philadelphia • San Francisco • St. Louis

HARSHAW
Tableted
CATALYSTS

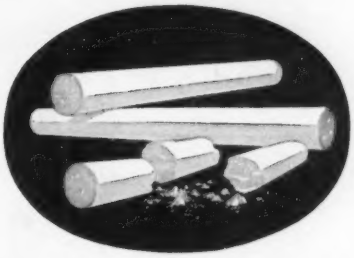
FROM **strong**



as rock!



TO *soft*



as chalk!

whatever you specify

Typical Harshaw Catalysts:

Aluminum Chloride Anhydrous
Boron Trifluoride
Boron Fluoride Addition Compounds
Hydrofluoric Acid Anhydrous
Alumina—active or inert
Chrome Alumina
Molybdena Alumina
Tungsten Alumina
Cobalt Molybdena Alumina
Copper-Chromium Oxide
Magnesia
Nickel
Vanadium
Zinc-Chrome

Harshaw Catalysts available in these forms:

Tablets
Extrusions
Powders
Granules
Spheres
Rings
Flakes

Use Harshaw Catalysts for these processes:

Hydroforming
Cyclization
Oxidation
Dehydrogenation
Hydrogenation
Dehydration
Desulphurization
Alkylation
Isomerization

Harshaw Catalysts—made exactly to your specifications of raw materials, chemical composition, and physical properties such as length, diameter, crushing strength, abrasion resistance, bulk density, etc. *AND* delivered *when you want them!*

Harshaw has the know-how—we pioneered in making customer specified catalysts. Harshaw has the facilities—we produce *carloads* every week!

We are to you like the druggist is to the doctor . . . write your catalyst prescription and depend on Harshaw to fill it.

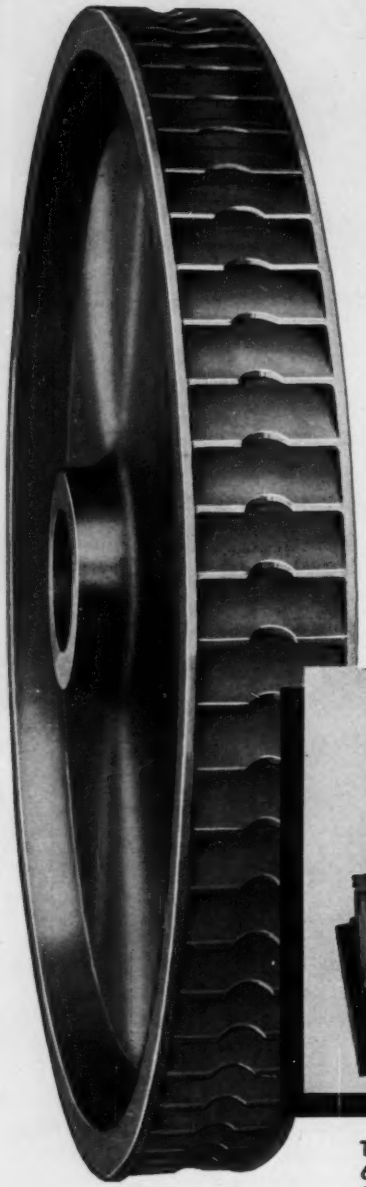
Our free booklet "Harshaw Catalysts" is yours for the asking. Write today.

The HARSHAW CHEMICAL Co.

CLEVELAND 6, OHIO

CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES
HASTINGS-ON-HUDSON • PHILADELPHIA • PITTSBURGH

TERRY SOLID-WHEEL *SIMPLICITY* MEANS *SUSTAINED* HP



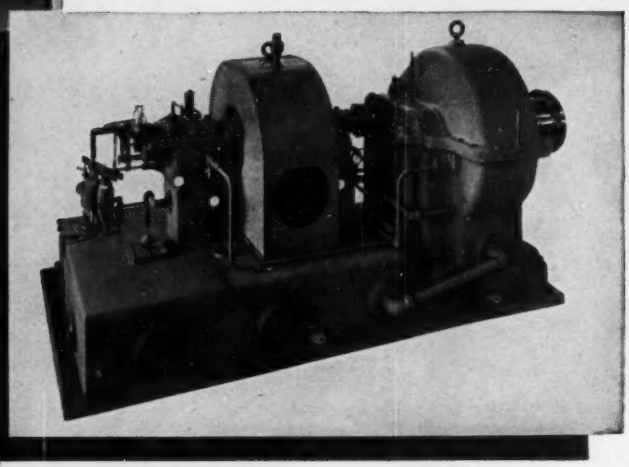
A Terry solid-wheel turbine is simplicity itself. Particularly the rotor. This is a single forging of special composition steel. And, unlike a built-up wheel, has no separate parts to loosen or work out.

Blade wear which might occur after years and years of usage is of little consequence, because the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets. Thus wear does not materially affect horsepower or efficiency.

The blades can't foul. There is a one inch clearance on either side of the wheel and, in addition, the blades are double rim protected. There is no need for close axial blade clearance, because the steam enters the buckets at right angles to the shaft.

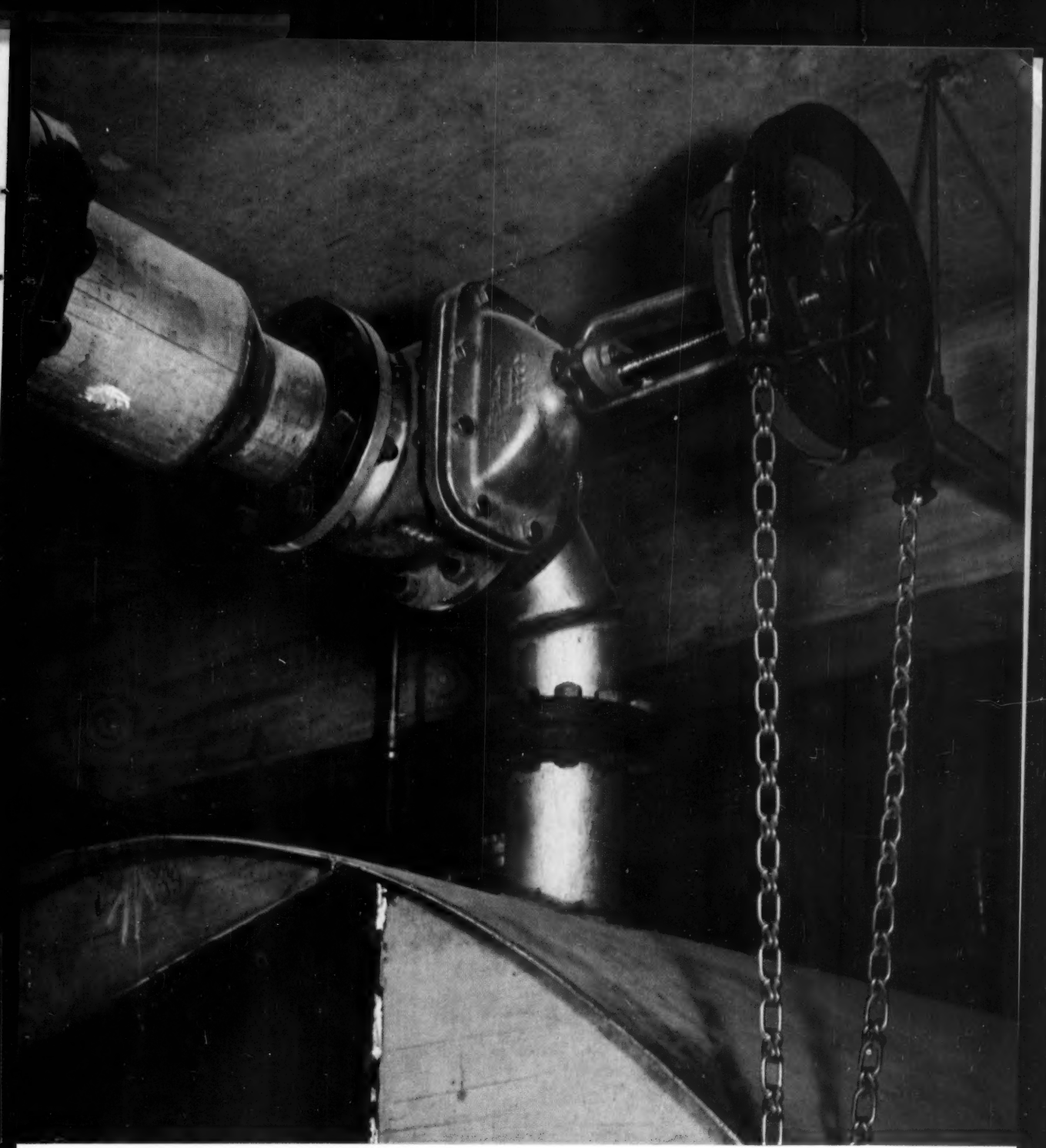
Perhaps you, too, can profit from Terry solid-wheel stamina. Bulletin S-116 gives complete details. Send for a copy today.

TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONNECTICUT



This Terry solid-wheel turbo-geared unit is rated 600 hp, 4000/650 rpm for 820 psi, 825°F steam with 275 psi back pressure.

TERRY



Film censor at work

At 950-acre Kodak Park, the film-producing plant of Eastman Kodak Co. in Rochester, N. Y., they take no chances on film contamination.

For example, in the operation shown here, a red-wheeled Aloyco stainless steel valve rules out of the picture dangerous rust and iron contaminants which would spoil the thick fluid which is called "dope." These valves control the flow of dope onto roll-coating wheels, where solvents are driven off with heat. The dry film base is then readied for the final coat of emulsion.

Today thousands of industrial processes are being safeguarded by Aloyco corrosion and contaminant resistant valves. Find out why their dependable performance makes them first choice for all types of vital flow lines. Write Alloy Steel Products Co., Inc., 1301 West Elizabeth Avenue, Linden, N. J.



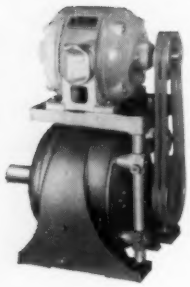
Subsidiary of Walworth Company

IN STOCK— answers to your POWER TRANSMISSION PROBLEMS

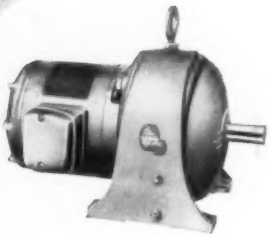
Foote Bros. LINE-O-POWER Drives











ALL MODELS, SIZES, RATIOS AVAILABLE FROM STOCK

Here's the widest selection of standard speed reducers available to you today—all from stock. Capacities range from fractional to 200 H. P., ratios to over 2700 to 1. Standardization of design and extra-capacity *Duti-Rated Lifetime Gearing* make them the most economical to buy for any standard speed reduction application. The most economical to maintain, too—highest quality workmanship and simplified, rugged construction offer top efficiency, longer life and trouble-free operation. Standardized interchangeable gearing minimizes spare parts stock requirements. Foote Bros. Line-O-Power drives will transmit power from any source and operate from any position. Input and output shafts can be easily modified to suit your particular needs.

Foote Bros. Line-O-Power offers you *the* complete line of drives pre-engineered and standardized for any or all of your power transmission problems—in stock to meet your needs efficiently and fast. *Write for complete catalog now.*

FREE... COMPLETE CATALOG



this trademark stands for the finest industrial gearing made

FOOTE BROS. Duti-Rated LIFETIME GEARING

T. M. REG. U. S. PAT. OFF.

FOOTE BROS.

Better Power Transmission Through Better Gears

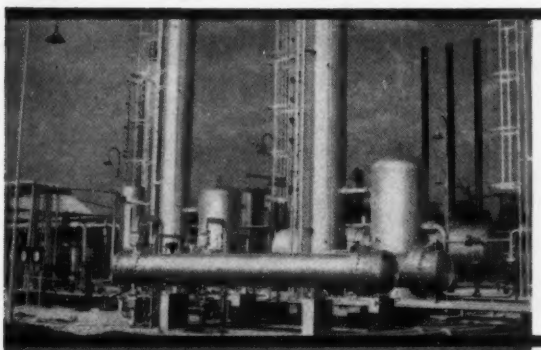
FOOTE BROS. GEAR AND MACHINE CORPORATION

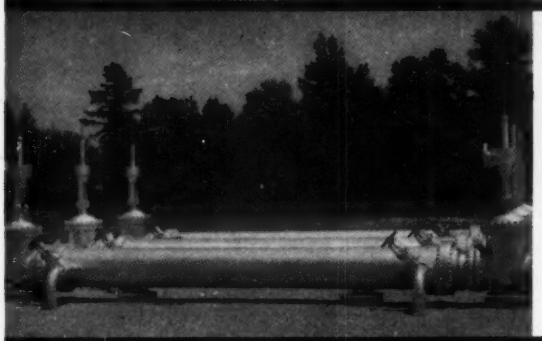
4545 South Western Boulevard, Department CI, Chicago 9, Illinois

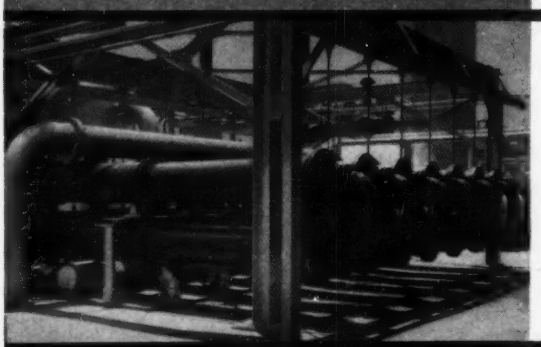
"THE BRAND OF PROGRESS"

By Heat Exchanger Specialists

▲ SYNOPSIS OF AD #11: Before any coded heat exchanger is shipped from Western Supply, it is rigidly inspected by three experts — the insurance company's inspector . . . the customer's inspector . . . and Western's inspector. This inspection, which takes place during and immediately following the pressure tests, results in stamping the exchanger shell with the vital information concerning the equipment. This is the end of a continuous line of quality control within the Western plant. The inspector's seal of approval on the exchanger brands it for safe and efficient operation.









WESTERN Exchangers for Refineries

As designers and fabricators of all types of heat transfer equipment, Western Supply has attained stature within the industry. A great amount of equipment is in service throughout the process industries and the company's customers range from the smallest to the largest names in the petroleum and chemical fields.

WESTERN Exchangers for Petrochemical Plants

Western's geographical position has proven to be a distinct advantage in following the rapid rise of the petrochemical industry. Having firmly established its reputation as a heat exchanger manufacturer for the petroleum industry the step to the similar problems of petrochemical heat transfer was not exceptionally difficult to make.

WESTERN Exchangers for Chemical Plants

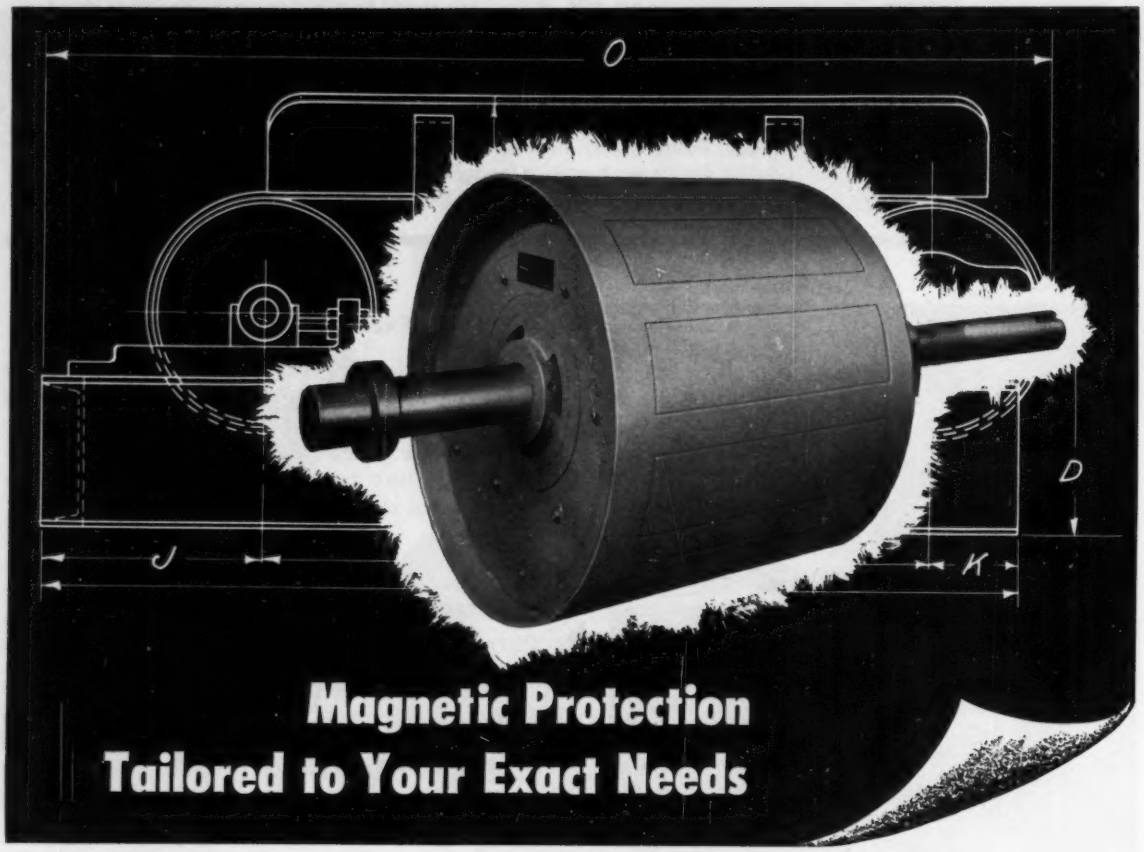
Western designs and fabricates shell-and-tube exchangers, atmospheric sections, telescopic exchangers, and reboilers for the refining, pipeline, chemical and petrochemical industries. The company is a member of the Tubular Exchanger Manufacturers Association, a group of independent heat exchanger manufacturers engaged in thermal and mechanical standardization of heat transfer equipment. For product quality . . . service flexibility — consult with Western Supply on your next heat exchanger requirements.

This concludes a series of 12 advertisements which we have titled, "The Brand of Progress". The series has been assembled under one cover and is available with our compliments upon your request. Please write for "The Brand of Progress", Western Supply Co., 2010 S. Utica, Tulsa, Okla.

WESTERN
HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
P. O. BOX 1888 • TULSA, OKLAHOMA

HUDSON-RUSH COMPANY—753 Gladstone Blvd., Shreveport, La.
130 Casa Linda Plaza, Dallas 18, Texas
PROCESS INSTRUMENTS & EQUIP. CO.—North Bldg., Charleston, W. Va.
H. W. SEVERANCE—Marion E. Taylor Bldg., Louisville, Ky.



Magnetic Protection Tailored to Your Exact Needs

When you specify a powerful, solidly built Stearns Permanent Magnetic Pulley for tramp iron removal, you get protection that's tailored exactly to your plant and product. Here's why:

First, Stearns magnetic specialists study every aspect of your installation . . . size of conveyor belt . . . speed of belt travel . . . size of material . . . depth of material . . . atmospheric conditions . . . available space . . . and many others. Then, Stearns interprets these factors and selects the magnetic pulley that will provide you with maximum plant protection and product purification.

Stearns offers both permanent and electro-magnet pulleys. A word from you places nearly 40 years of research and engineering experience at your disposal. Write for bulletin 350C-1.

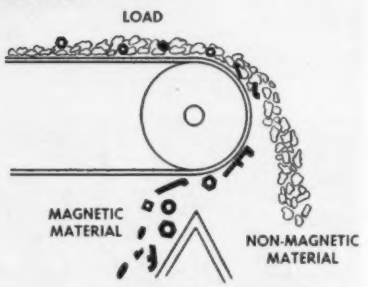


Diagram showing how Stearns magnetic pulley removes tramp iron.

Check These Advantages

- **PULLING POWER** — Design and position of Alnico magnets provide a uniform, powerful pulling force.
- **NO OPERATING EXPENSE** — No current needed. Easy to install. Set it and forget it.
- **OPERATES ANYWHERE** — Inside or out, moist air or dry — Stearns permanent magnets work anywhere.
- **BELT STAYS PUT** — Crown face insures proper belt travel. Special lagging available for conveyors of long centers.

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

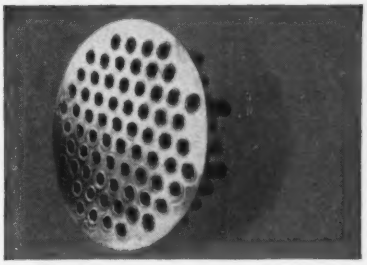
STEARNS MAGNETS

STEARNS MAGNETIC, INC. 629 SOUTH 28TH STREET, Milwaukee 46, Wisconsin

1063

TITANIUM

SOLVES TOUGH CORROSION PROBLEMS



HOT NITRIC ACID at pressures of 300 psi took a high toll of stainless-steel condenser tubes at a Du Pont plant—until this titanium "top-hat" was installed. Fabricated entirely of titanium, it provides a protective sleeve inside the top 3 inches of the condenser tubes. The unretouched photo shows the clean, uncorroded appearance of the "top-hat" after 14 months' continuous service. The titanium tube sheet, tubes and welds have essentially the same appearance as when installed . . . show evidence of being able to serve indefinitely.



HIGH-VELOCITY STEAM and biting hydrochloric acid were cutting the service life of cast-iron steam diffusers to less than 3 months at a Du Pont Pigments plant. Bronze and corrosion-resistant alloys were tried, without improvement. Then a diffuser fabricated from titanium was installed. This proved to be the answer. The photo shows the condition of the titanium diffuser after 2 years' service—a period ten times the average life of other diffusers. Compare the uncorroded appearance of the titanium diffuser with the cast-iron flange, which shows severe acid attack.

A partial list of other environments where TITANIUM offers unmatched corrosion resistance . . .

CORROSIVE CHEMICALS	CONDITIONS	POSSIBLE APPLICATIONS
Ferric Chloride	0-30% at 100° C.	Process piping
Sodium Chloride	All Conc. at 100° C.	Kettles, heat exchangers
Chlorine-Saturated Water	Room Temperature	Proportioning equipment
Wet Chlorine Gas	75° C.	Recovery equipment, electrolytic cells
Chromic Acid	10% and boiling	Plating equipment
Sulphuric-Nitric Acid Mixture	40% sulphuric, 60% nitric at 35° C.	Acid heaters, nitrators, auxiliaries
Calcium Hypochlorite	6%-35° C.	Filter presses, processing equipment
Zinc Chloride	20%-100° C.	Coils, pans, evaporators

TITANIUM MAY BE THE ANSWER TO YOUR CORROSION PROBLEM

If you're looking for a way to improve your product . . . or cut production and maintenance costs by extending the service life of essential equipment . . . it may pay you to investigate titanium. As a pioneer *supplier* of titanium sponge, Du Pont has the experience to offer you expert technical help with your evaluation tests . . . can put you in touch with manufacturers best equipped to work with you on your particular product or application. Considerable fabricating know-how and a wide variety of mill shapes are available now to help you use titanium to solve your corrosion problems. For more detailed information on titanium, just check the coupon below, or write: E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Wilmington 98, Delaware.



TITANIUM SPONGE

PIONEERED COMMERCIALLY BY DU PONT

DU PONT

REG. U. S. PAT. OFF

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.)
Pigments Department CE- 3
Wilmington 98, Delaware

☐ Please send me your new technical bulletin on the corrosion-resistant properties of titanium.

☐ Please send me your general booklet on titanium.

I am interested in using titanium for:_____

_____

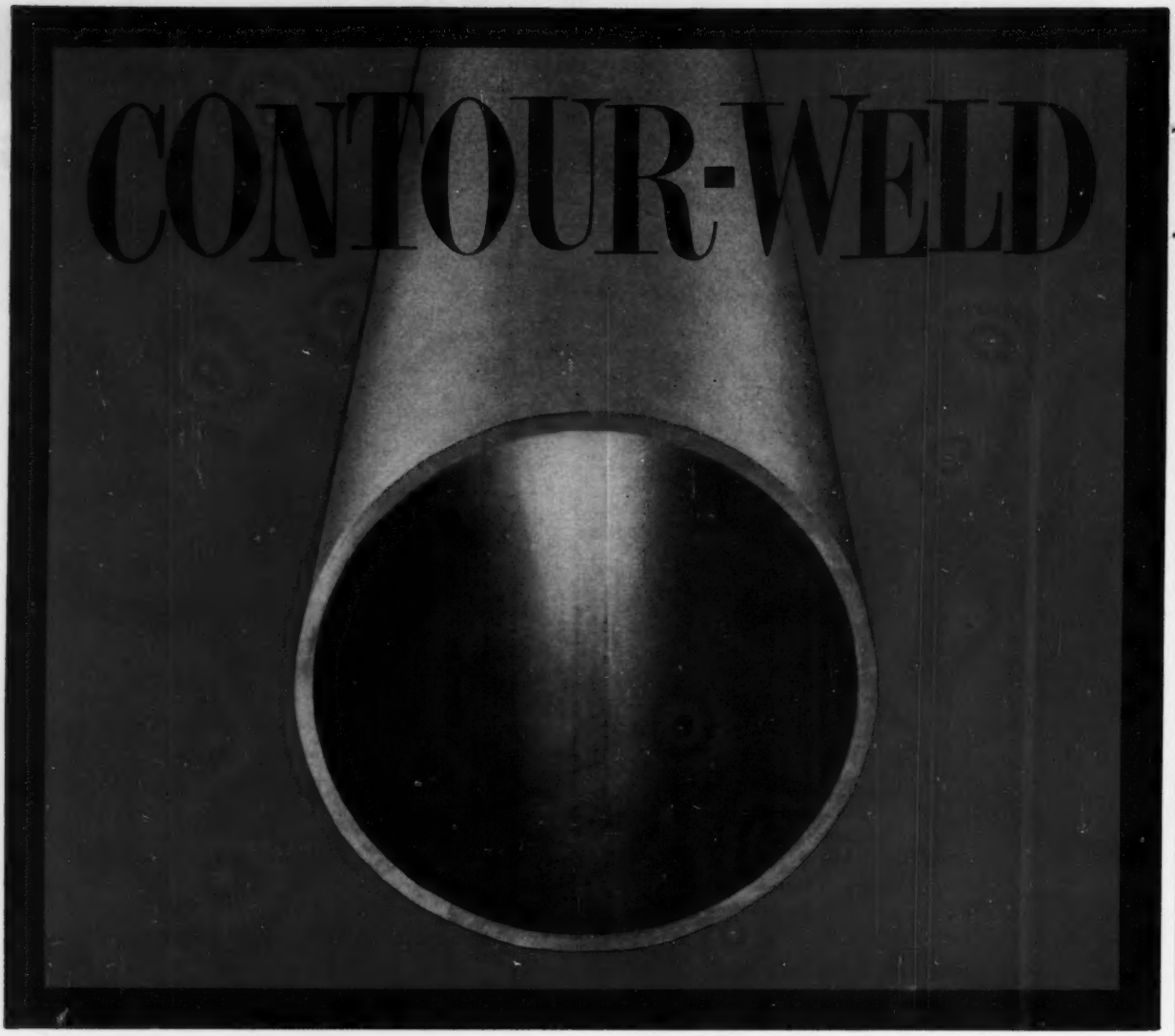
*Name*_____

*Firm*_____ *Position*_____

*Address*_____

*City*_____ *State*_____

CONTOUR-WELD

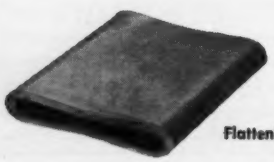




Flare and Flange



Pressure (Tubing)

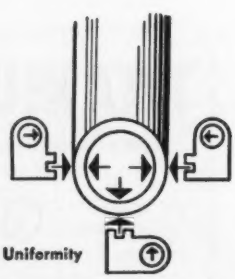


Flattening

CONTOUR-WELD PIPE...BEST BY ANY TEST YOU CAN NAME



Reverse Bend (2⅜" O.D. x .154 Wall)



Uniformity

new stainless pipe

with a weld so smooth you can't even feel it

Run your finger over the weld area inside Trent's new *Contour-Welded** pipe. We doubt if you can even feel the weld. It's that smooth! There's no weld bead . . . no undercut . . . no place for corrosion or erosion to get a start.

Here's the reason: *Contour-Welding* is an entirely different method of producing welded pipe and tubing. It puts gravity to work to pull down the molten weld-metal to conform with the exact contour of the pipe. That means a smooth, clean weld practically indistinguishable from the pipe itself.

Contour-Weld Means Trent's Better Than Ever

As always, this new TRENTWELD pipe and tubing is made from uniformly rolled stainless strip. Wall thickness is always the same throughout the pipe . . . and *Contour-Welding* brings this same high uniformity to the weld zone itself. All this, plus Trent's superior cold-working methods, gives you a stronger pipe or tube, with smoother flanged or flared ends.

Try new TRENTWELD pipe or tubing on your next job. It's available in any gage, for all applications including high-pressure hydraulic lines . . . high-velocity systems . . . lines carrying corrosive chemicals. And new *Contour-Welded* tubing is available in most grades, including Hastelloy, Zirconium, Zircoloy, Titanium and 19-9-DL. You'll find that TRENTWELD can't be beat by any other pipe – welded or not.

*Contour-Weld is the trade mark of the Trent Tube Company for its process of welding pipe and tubing which is protected under U.S. Patent 2,716,692.

Why Trent's Exclusive Contour-Weld Process Means Smoother Welds . . .



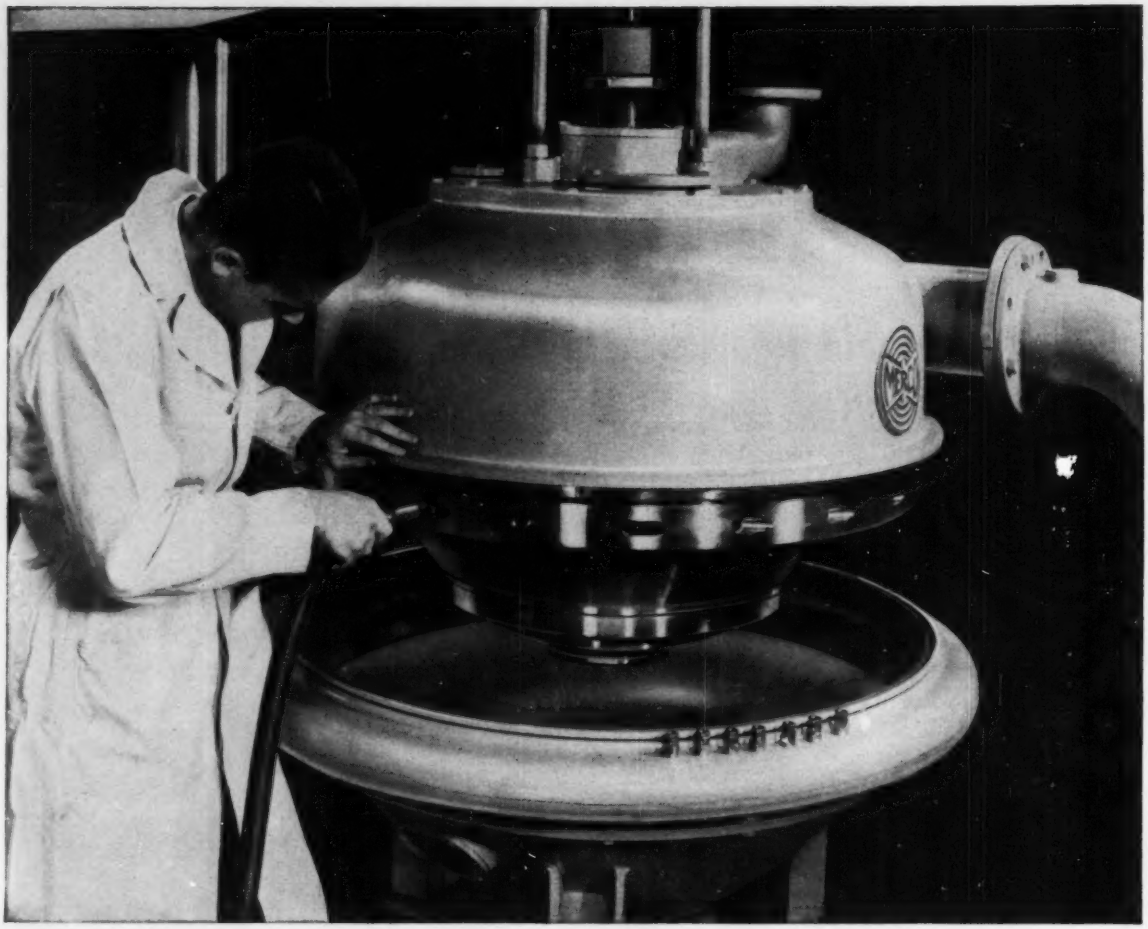
Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the I.D. surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.



But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

TRENTWELD **STAINLESS STEEL TUBING**

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)



The separating force produced by this Merco centrifuge is made practical by the strength of its high speed rotor bowl, machined from cast stainless steel with a high nickel content, produced by Electric Steel Foundry Company, Portland, Oregon. Weight of the all-stainless steel rotor assembly on the unit shown above totals 1600 lbs. This centrifuge has a large continuous through-put capacity. In many plants, Merco units run continuously for 24 hours, virtually unattended. Manufactured by Merco Centrifugal Company, San Francisco, California.

Up to 9000G's developed . . .

thanks to strength of rotor cast in stainless . . . that licks corrosion and erosion

Merco Centrifugal Co. tested scores of materials for their centrifuge rotors. And found what they needed in cast chromium-nickel molybdenum stainless steel (ACI Type CF-8M.) These castings safely answer the high strength demands, and in addition, provide resistance to both corrosion and erosion.

Read what a typical customer reported about the performance of a Merco rotor machined from this cast stainless steel containing 10 to 12% nickel:

> ". . . shows no signs of corrosion after 12 years' service in slurries of warm weak sulfurous and lactic acids, SO_2 vapors, alternate wetting and drying, with liquid and solids passing over the metal surfaces at very high speeds."

Despite corrosives and suspended solids, this rotor has operated for more than a decade with no apparent damage from erosive action. Many similar records confirm that Merco engineers made a wise choice, years ago, when they selected Type CF-8M stainless castings for rotors.

Alloys containing nickel may help *you* strengthen equipment, combat corrosion and erosion, or meet other specific needs. When you face a metal difficulty, send us details. We'll submit suggestions based on wide practical experience. Write for List A of available publications. It includes a simple form that makes it easy for you to outline your problem.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

POSITIVELY EXCLUDES LIQUIDS, FUMES . . .

APPLETON

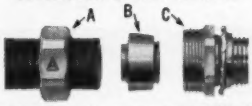
INDUSTRY'S MOST ADVANCED LINE

"ST" SERIES CONNECTORS*

for Liquid Tight Flexible Conduit



Why APPLETON "ST" Series Connectors Are Better



Precision turned compression nut (A) slips over liquid tight conduit. Brass Ferrule (B) screws into conduit with sleeve covering conduit. Tightening compression nut onto connector body (C) provides a positive seal and ground between flexible conduit and connector.



Cross section of completed connection shows how tapered end of nut compresses ferrule wall . . . seals perfectly and gives positive ground between conduit and connector.

The Only Fittings of Their Kind . . . Provide Positive Wiring System Protection

• APPLETON *"ST" Series Connectors* have an exclusive brass ferrule, and unique construction to make it your best connector buy for use with liquid tight flexible conduit! Nothing to come loose, deteriorate, crack or break. APPLETON *"ST" Series Connectors* stay tight . . . positively exclude liquids, fumes, chips, shavings and other foreign matter from electrical systems. Recommended by many electrical engineers. And, since the threaded brass ferrule screws in and crimps on there is *a perfect seal* and *permanent* ground . . . maintaining voltage in ground circuit unfailingly within 10 millivolts drop. *"ST" Series Connectors* are one more reason why APPLETON is . . .

TODAY, MORE THAN EVER . . .

The Standard for Better Wiring

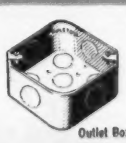
*Patent Applied for

Sold Exclusively Through Selected Wholesalers

APPLETON ELECTRIC PRODUCTS

Also Manufacturers of:


Explosion-Proof Fixtures

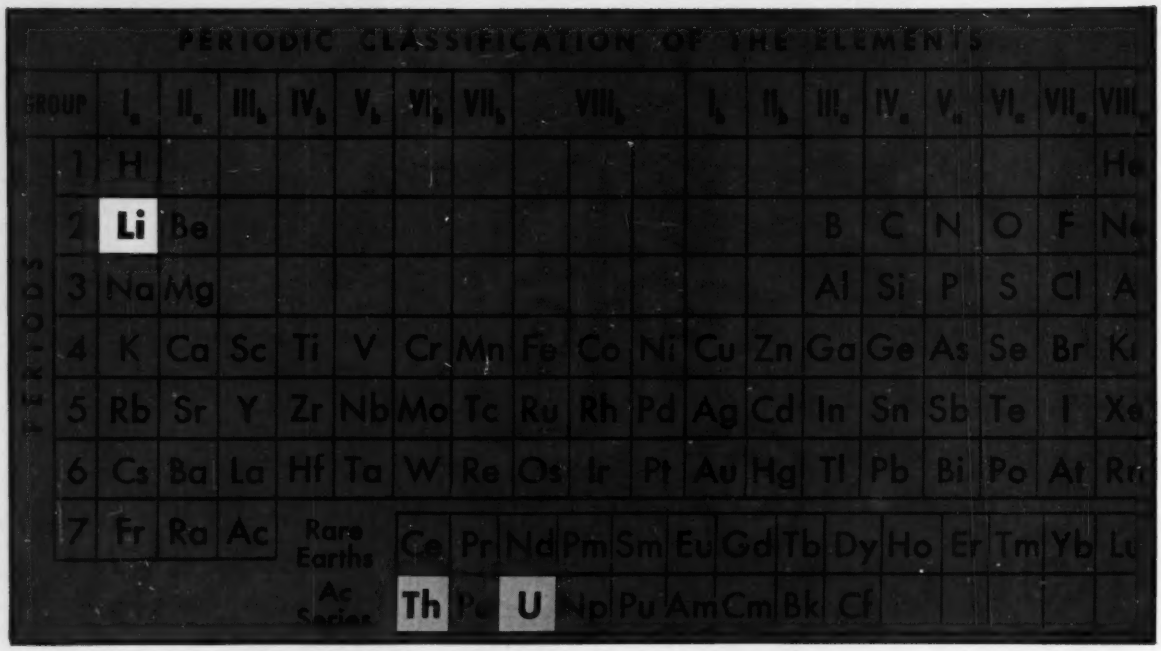

Outlet Boxes


"MI" Series Connectors


Industrial Lighting

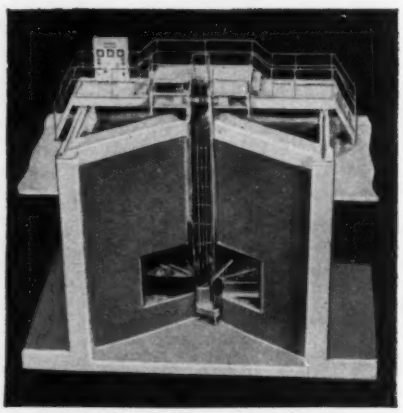

Malleable Iron Unilet Fittings

APPLETON ELECTRIC COMPANY • 1742 Wellington Avenue • Chicago 13, Illinois



LITHIUM in the ATOMIC FUTURE

Only in recent years has mention of Lithium in nuclear energy been made. For the past 12 years, however, the technical staff of Lithium Corporation has been accumulating know-how on lithium. The contributions made to the comparatively small store of knowledge on this interesting element are material. Now, with our country on the threshold of peacetime nuclear power, Lithium Corporation stands ready to assist the creators of tomorrow's power. Lithium metal, two metal derivatives, and 15 salts are available for study. You are invited to share the benefits of our use-research into lithium. Write for technical data sheets on this miracle element. It could mean a great deal to you.



Model AMF Atomics Inc. Research Reactor

. . . trends ahead in industrial applications for Lithium

LITHIUM CORPORATION OF AMERICA, INC.
2505 RAND TOWER
MINNEAPOLIS 2, MINN.

MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, North Carolina • Cat Lake, Manitoba • Amos Area, Quebec • BRANCH SALES OFFICES: New York Pittsburgh • Chicago • CHEMICAL PLANTS: St. Louis Park, Minnesota • Bessemer City, North Carolina • RESEARCH LABORATORY: St. Louis Park, Minnesota

BAD AIR IS COSTLY...



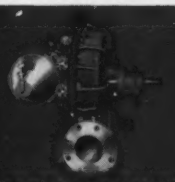
... as compared to the blower that keeps air fresh

Your men can't produce at top efficiency when stagnant, hot or fume-filled air robs them of their energy.

Wherever bad air slows down production . . . in shipholds, tanks, drums, boilers or other places where men need fresh, cool air . . . a Coppus Blower becomes both a safety device and a production tool.

Portable and easily adaptable for special purposes, Coppus "Blue Ribbon" Blowers and Exhausters fit all your "fresh air" requirements. The Coppus "Blue Ribbon" means premium performance at ordinary cost. Check and mail the coupon for specific information. Sales offices in THOMAS' REGISTER. Other "Blue Ribbon" Products in CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG, BEST'S SAFETY DIRECTORY, MINING CATALOGS.

OTHER
COPPUS
"BLUE RIBBON"
PRODUCTS



HORIZONTAL TURBINE
Six frame sizes —
1 to 150 horsepower



VERTICAL TURBINE
Six frame sizes —
1 to 150 horsepower



FANMIX GAS BURNER



FANMIX GAS-OIL BURNER

MAIL THIS COUPON To Coppus Engineering Corp., 223 Park Avenue, Worcester 2, Mass.

PLEASE SEND ME INFORMATION ON SUPPLYING FRESH AIR TO MEN WORKING:

- ☐ In tanks, tank cars, drums, etc.
- ☐ in underground cable manholes.
- ☐ in aeroplane fusilages, wings, etc.
- ☐ on coke ovens.
- ☐ her processes.
- ☐ on boiler repair jobs.

COOLING:

- ☐ motors, generators, switchboards.
- ☐ wires and sheets.
- ☐ general man cooling.
- ☐ around cracking stills.
- ☐ exhausting welding fumes.
- ☐ stirring up stagnant air wherever men are working or material is drying.
- ☐ drying of walls, sheets; etc., after treated with coating material.

NAME.....

COMPANY.....

ADDRESS.....

CITY.....

(Write here any special ventilating problem you may have.)

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**



No Day is FRYDAY

with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result—you expect and get longer motor life.

The engineered partner of A-C motors is Allis-Chalmers control.

Get Complete Information

As a new machinery component or as replacement, specify Allis-Chalmers. Discuss your particular application with your nearby A-C distributor, A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-4853

Reynolds Pioneering in Aluminum Chemicals



Write for Data Sheet R-2003

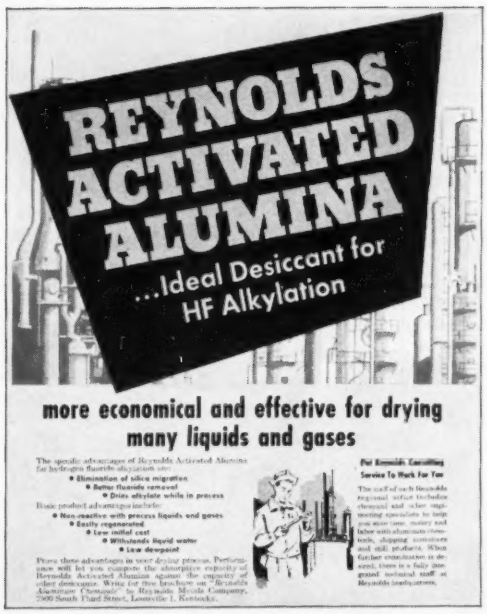
Improved Aluminas for Expanding Markets

- **All white hydrates**
- **High quality desiccants**
- **Highly calcined aluminas**

These new aluminas made important news in the chemical industry in the past three years. Products were improved, processes were made more efficient . . . without increasing costs.

The three announcements reproduced on this page speak volumes for Reynolds pioneering in the field of aluminum chemicals.

If you would like to know more about these developments—and others—call the Reynolds office listed under "Aluminum" in your classified directory or write for Product Data Sheets. *Reynolds Metals Company, P.O. Box 1800-CK, Louisville 1, Kentucky.*



Write for Data Sheet R-2101, R-2102



Write for Data Sheet R-5002, R-5003

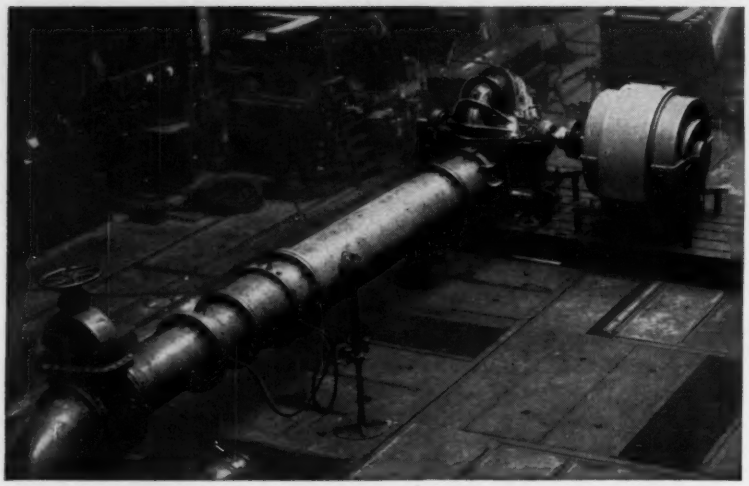
See Reynolds New Program "Frontier"—Sundays on NBC-TV

REYNOLDS CHEMICALS

FROM THE MAKERS OF REYNOLDS ALUMINUM

Keep your eye on WORTHINGTON

Pump research primes pump progress





TEST STAND CAPACITY UP TO 100,000 GPM is provided at Worthington's Harrison plant *(above)*. Built over a man-made half-acre lake, the test stand is used as a production tool to check pumps from fractional horsepower up. This flexibility comes in handy—in one line alone Worthington can put together 60,000 different standard pumps out of 650 parts in six standardized sets of liquid ends.

DIRECTING PUMP TEST OPERATIONS from central control room *(left)* where special measuring instruments speed collection of performance data. Worthington pump specialists can afford to be objective in considering your pump application problem. They select from the most complete line of pumps offered by any manufacturer.

We have a lot of experience at Worthington—more than 114 years of it—and we're picking up more all the time.

But technology advances every day. Each step forward brings with it new and unsolved pumping problems. That's why Worthington's research and development program is continuous. That's also why we like to work with you during planning to get the jump on problems before they reach the costly stage.

Experts for every problem

For your day-to-day pumping problems, our sales engineers are thoroughly trained in pump applications in every field, and can usually supply the right answer fast. Naturally, for the really tough ones, our staff engineers back them up with all the equipment and facilities of our shops and laboratory. In addition, factory-trained troubleshooters are available to cope with any problem that may arise in the field.

From cat-cracker to atom-cracker

Our specialists, covering all major industries, work as a team. Together, they bring to bear on any problem a vast store of experience. They've successfully solved pumping problems and helped pioneer new developments in public works, atomic energy applications, the oil industry, and the chemical industry —to name a few.

So keep your eye on Worthington; we probably have a money-saving answer to your pumping problems. C-5.1



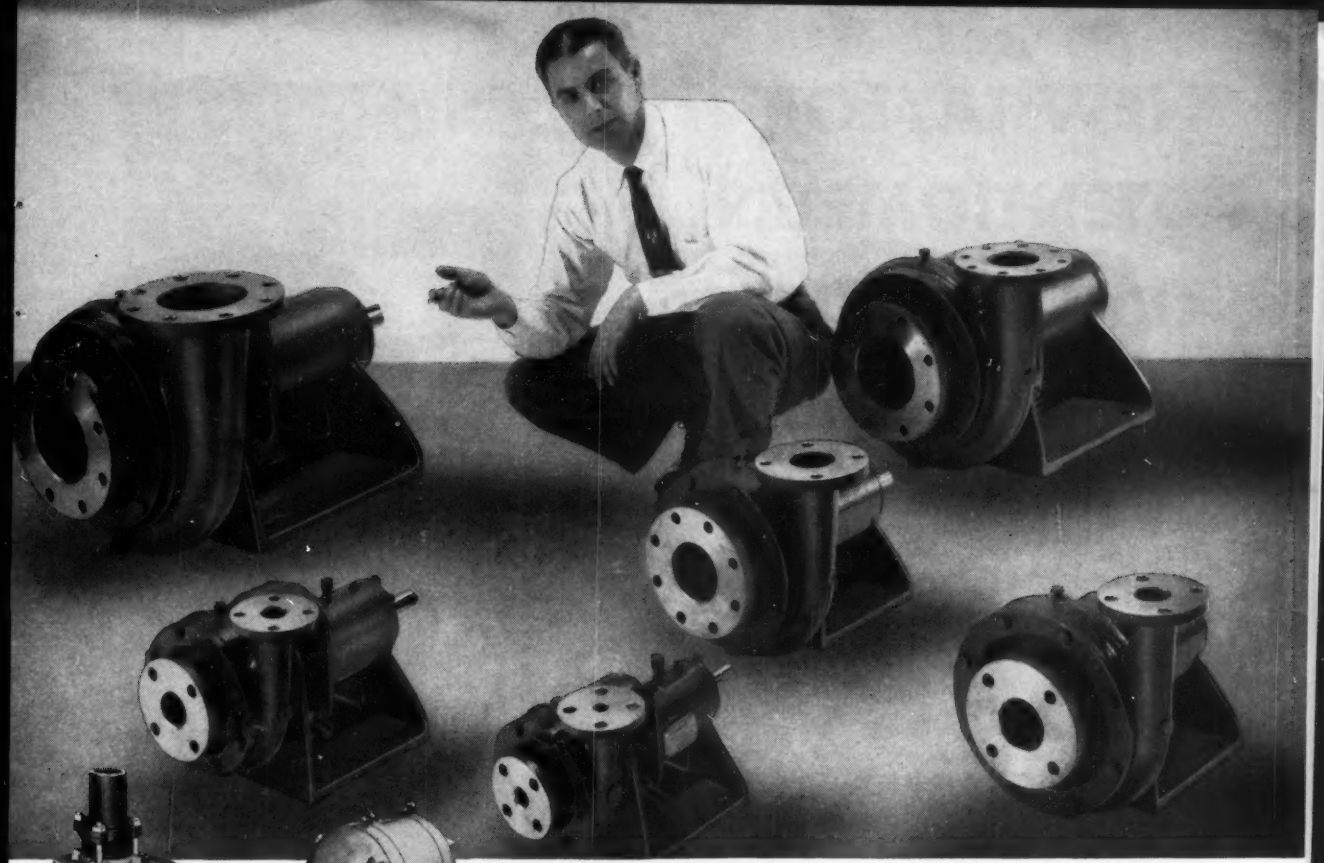
WORLD'S FIRST ATOMIC-POWERED SUBMARINE, *NAUTILUS*, undergoing sea trials. In atomic development since 1941, Worthington recently built special engine room equipment for both atomic submarines, *Nautilus* and *Sea Wolf*. Worthington continues to figure prominently in supplying this new field of atomic energy, keeping pace with its new and rapidly changing requirements.

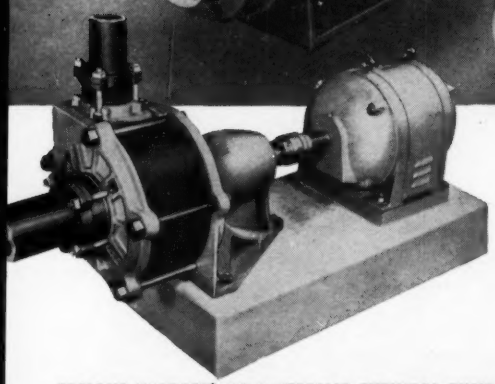


EUTECTIC CASTING, used in making standard Worthington pumps, frees engineer from casting restrictions. Formerly, design of impeller and diffuser blades had to allow hand withdrawal from fragile sand core. Eutectic casting uses a low-melting-point alloy to form blades, melting this alloy out during baking. This permits design flexibility for maximum hydraulic performance.

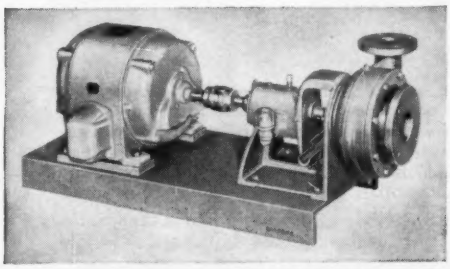


VITALITY OF WORTHINGTON RESEARCH PROGRAM is shown by the more than 300 articles in the technical press during the past five years by Worthington people. This flood of informative technical literature not only reflects our ability to keep pace with the changing hydraulic requirements for modern pumps, but also highlights the important contributions by Worthington to the knowledge of pumps.





FAMOUS KARBATE* NON-METALLIC CHEMICAL PUMP, made of impervious graphite by National Carbon Company. Now you'll be able to buy this pump from Worthington. Karbate pumps include motor-mounted (close-coupled) and frame-mounted units with capacities ranging from 5 to 1500 gpm at heads to 110 feet at conventional motor speeds.



WORTHITE TYPE CNG CENTRIFUGAL CHEMICAL PUMP. Super-stainless Worthite provides best all-round metallic corrosion resistance in a standard pump. Manufactured in 27 standard sizes, it assures you of complete hydraulic coverage up to heads of 235 feet and capacities of 2500 gallons per minute. Worthite type CNG pumps are available with standard stuffing boxes, with Teflon seal cage arranged for independent cooling liquid, or with external mechanical seal.

Now Worthington offers you the widest standard corrosion-resistant pump line

as Karbate* impervious graphite supplements Worthite

Worthington Corporation is now marketing Karbate brand centrifugal pumps, manufactured by National Carbon Company, a Division of Union Carbide and Carbon Corporation, in addition to our Worthite centrifugal chemical pumps.

In Karbate pumps, parts in contact with the liquid pumped are made of impervious graphite, making the pumps applicable for many corrosive services where conventional metals or alloys are unsuitable.

Worthite pumps already form the broadest line of metallic centrifugal pumps in the industry. This coverage is now completed by the addition of the non-metallic Karbate Brand Impervious Graphite Pumps. You'll find Worthite and Karbate pumps your best bet for virtually 100 percent of corrosive applications.

Worthite is a high-nickel, high-chromium, molybdenum alloy steel, with 0.07 percent maximum carbon content. It is stainless and its stabilizing elements tend to prevent intergranular corrosion.

Write today for copies of bulletins W-350-B14A and W-350-B18 describing in detail Worthite and Karbate centrifugal chemical pumps. Worthington Corporation, Standard Pump Division, Harrison, N. J. C.5.1A

Reg. Trademark of Union Carbide and Carbon Corporation.

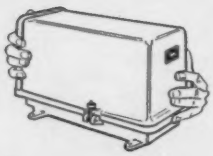
WORTHINGTON

THE WORLD'S BROADEST LINE
ASSURES YOU THE RIGHT PUMP FOR EVERY JOB

CENTRIFUGAL • ROTARY • STEAM
POWER • VERTICAL TURBINE

NEW TAYLOR POTENTIOMETER TRANSMITTER

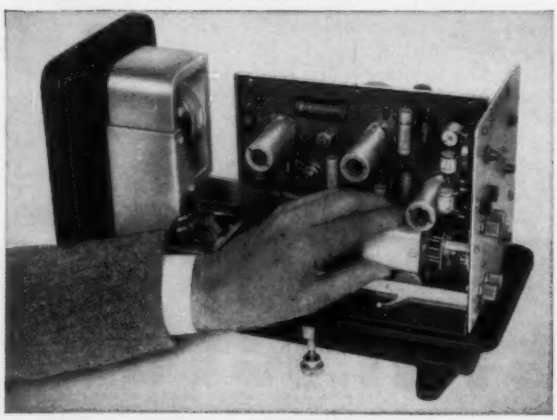
"most practical instrument of its kind!"



TAYLOR'S years of experience and knowledge of the requirements of the processing industries are reflected in this ingenious electronic-pneumatic instrument. The TRANSET* Potentiometer Transmitter can be used with a wide variety of electrical primary elements. It is especially adaptable where conditions require pneumatic controllers and receivers and where conventional measuring circuits have not proved adequate. Check these features:

1. Automatically, Continuously Standardized with complete electronic balance, permitting optimum response adjustments. No slide wires or motor drive.
2. High Input Impedance. No need to match resistance of leads.
3. Output Impedance is practically infinite. Its 0-5 milliamp signal can perform multiple auxiliary functions without affecting accuracy of pneumatic signal.
4. Normal Load is automatically inserted when amplifier is removed for service.
5. Modern Printed Circuits insure uniform performance. Test terminals provided to simplify trouble shooting.
6. Test Jack on front panel permits easy monitoring of output current. Convenient pin jacks provided for checking standardization voltage.
7. Purged Cast-aluminum Case is moisture and corrosion proof.

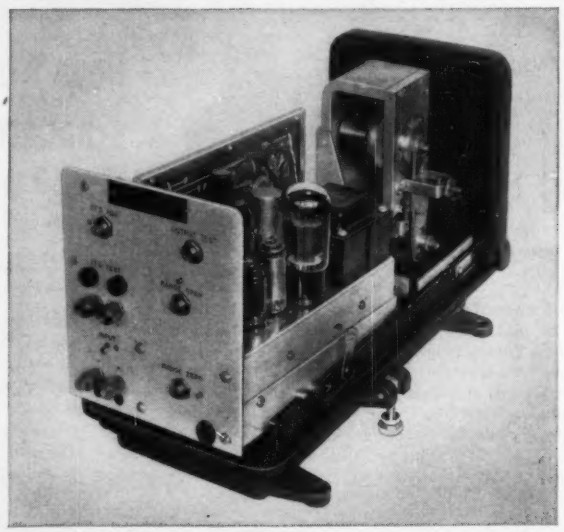
*Reg. U.S. Pat. Off.



Plugging in the Input Circuit Board. It can be quickly adapted for use with different primary elements by simply plugging in the corresponding input circuit; e.g., for thermocouple applications cold junction compensation is provided in the plug-in circuit board. One instrument can therefore be used as a spare wherever a transmitting potentiometer is used.



Plugging in the Transducer. This exclusive plug-in feature applies to both the transducer and the amplifier. Means quick, easy removal for service; minimum instrument down-time; checking can be done in the shop where full facilities are available. Also permits separate calibration.



Plugging in the Amplifier. See how easily units are locked into the chassis. Also note screwdriver adjustment of range span and zero suppression by use of unique potential dividers. Exclusive Taylor vernier adjustment permits resolution of 1 part in 100,000. Transducer can be omitted when only logging and scanning or other auxiliary electrical functions are required.

Write for Bulletin **No. 98262.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Taylor Instruments
MEAN ACCURACY FIRST

WHY REPLACE...



REPLACE...



REPLACE...



when process lines of CHASE® COPPER TUBE LAST SO MUCH LONGER!



Nothing mysterious about *why* process lines of Chase copper tube give such extraordinary service. It's just that they're naturally corrosion resistant...can't rust!

What's more, the careful manufacturing process at Chase mills puts a mirror-like finish on the inside surfaces. Clogging deposits can't get a foothold—so Chase copper tube stays free-flowing far longer than rustable process lines.

Such smooth interiors keep fluid friction down to a minimum, too! Pumps do their job with less effort and strain. Even the heaviest industrial fluids move more easily!

Get all the facts on longer-lasting Chase copper tube for process lines. Contact your Chase wholesaler or the Chase warehouse nearest you—today!

Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass & Copper

Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury



(Courtesy A. H. Mathieu & Company)

MANHATTAN Rubber Linings Assure Permanent Protection against Corrosion, Contamination, Abrasion

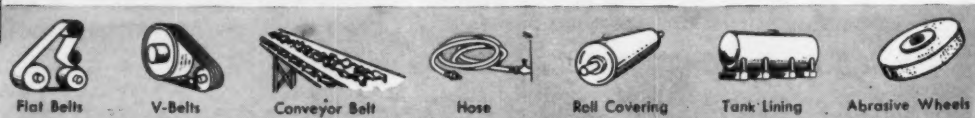
You get *real* protection . . . *permanent*, positive protection against losses due to corrosion, contamination and abrasion with Manhattan Rubber Linings. That's because Manhattan engineers have developed a special method of bonding rubber to metal so securely that actual on-the-job tests have proved it can't be separated! Manhattan Rubber Linings are made from thick, calendered sheets of natural or synthetic rubber, whichever is best suited, for maximum durability. They expand and contract with the metal under temperature changes—won't harden or crack. Their resistance to most acids, caustics and alkalis is as permanent as is possible to make them.

To make certain your Manhattan Rubber Lining is flawless and permanent, every Manhattan Lined Tank is tested under high voltage to detect any possible imperfections. More than 60 years of research and manufacturing "know-how" at Manhattan have led to the development of many high quality linings . . . each designed for specific application. Regardless of the size or shape of your processing equipment, Manhattan has the facilities to handle your job . . . the most modern and complete available today. Equipment too large to be shipped can be field lined and vulcanized by skilled Manhattan crews. For rubber lining that lasts longer, contact an R/M representative at the Manhattan Rubber Lining plant nearest you.

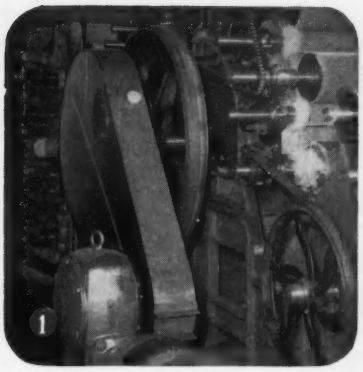
RM 621

RUBBER LINING PLANTS AT PASSAIC, N. J. and NORTH CHARLESTON, S. C.
MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

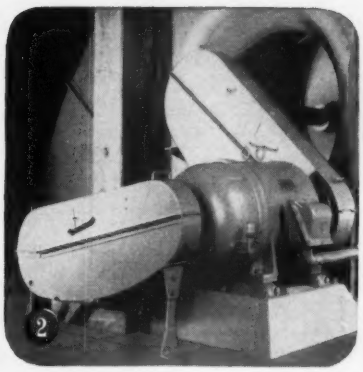
RAYBESTOS-MANHATTAN, INC.



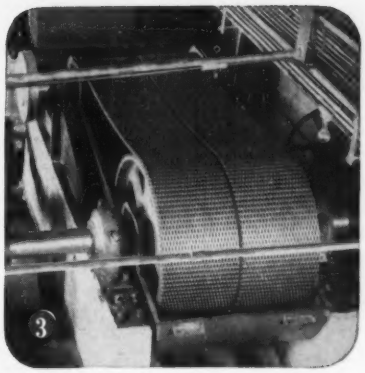
Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls



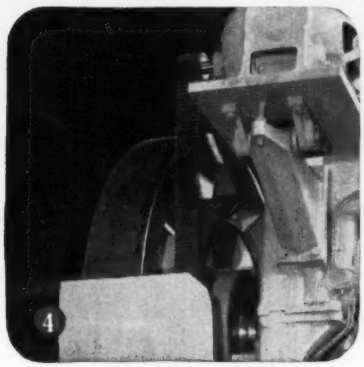
1 ADVERSE OPERATING CONDITIONS. Humidity, heat, cold do not lower Link-Belt Silent Chain's better-than-98% efficiency.



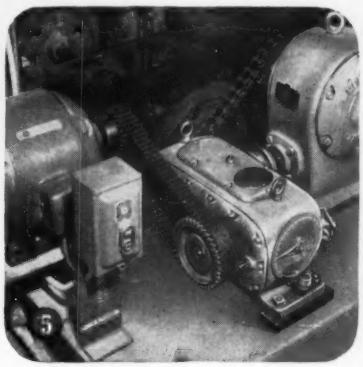
2 UNFAILING SAFETY. Dependability assures continued production. On above tunnel ventilators, Link-Belt drives protect human life.



3 LARGE OR SMALL HP. A versatile line, Link-Belt Silent Chain drives are available from fractional to thousands of horsepower.



4 LARGE RATIOS. Link-Belt Silent Chain operates efficiently on extremely short centers at ratios as high as 10-to-1.



5 LIMITED SPACE. Easy to assemble in close quarters, Link-Belt Silent Chain permits built-in drives, compact housings.



6 HIGH SPEED. After 13 years on this newspaper press at speeds up to 4700 fpm, Silent Chain is still efficient.

Big reasons why LINK-BELT Silent Chain

is specified for so many drives:

WHEN using a Link-Belt Silent Chain Drive, you can look forward to better-than-98% efficiency throughout its long operating life. What's more, silent chain offers the sureness of positive tooth-to-tooth action plus the flexibility of a belt. As for economy, silent chain is often lower in cost than other drives far less efficient.

Find out for yourself why so many of today's demanding drives incorporate Link-Belt Silent Chain. Ask your nearest Link-Belt office or distributor for Book 2425, containing complete information.

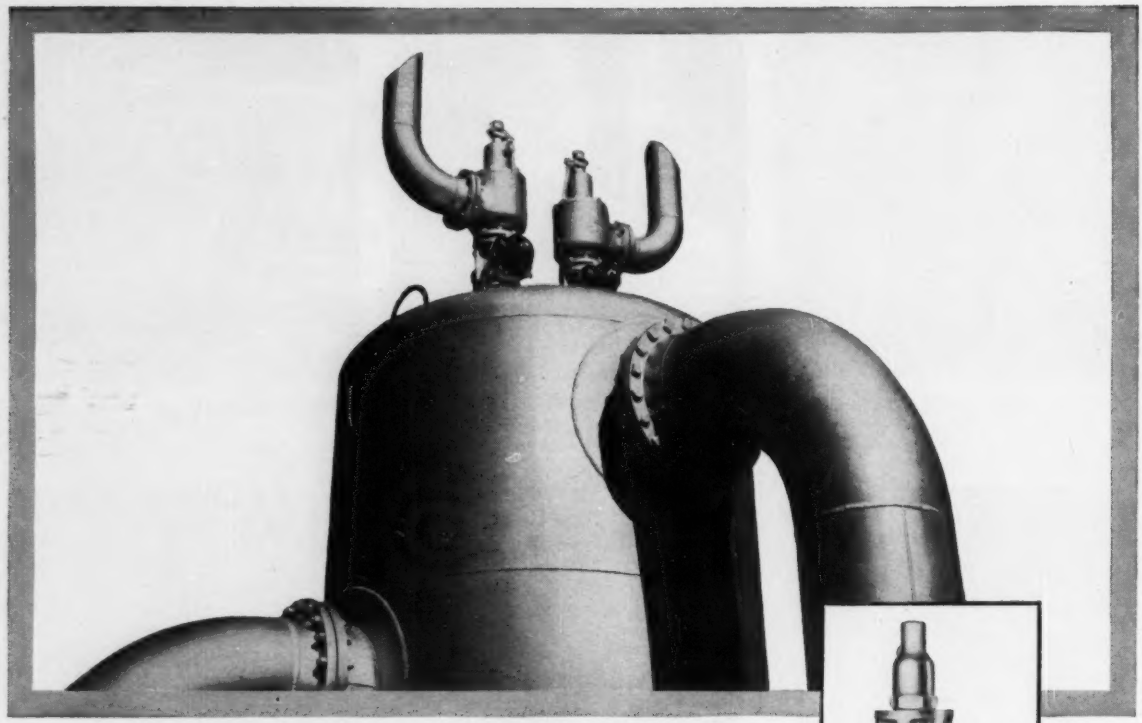
LINK-BELT

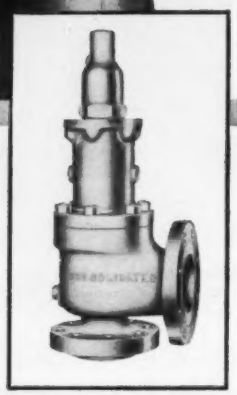
SILVERSTREAK SILENT CHAIN DRIVES

Here's why LINK-BELT Silent Chain offers you more drive per dollar

- Lower cost—often lower in first cost, always lower in ultimate cost.
- Longer life—trouble-free performance for 20 to 30 years is common.
- No dismantling machine or removing sheaves for repairs.
- Better than 98% efficiency.
- Maintained ratio assures full productive capacity.
- Slipless action assures a better product.
- Easy to install.
- Safe to employees—operates in oil-retaining casing.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,719





★ Economical "2 in 1" Design
★ Peak Performance
★ Absolute Protection
★ Maximum Interchangeability

CONSOLIDATED SAFETY RELIEF VALVES GIVE YOU ALL FOUR—AND MORE

Consolidated Safety Relief Valves satisfy *every* requirement of the most advanced processing facilities. Valve action is *consistently* positive. You get peak performance even where discharge lines are long or there is low "superimposed" back pressure in the relieving system!

The Standard type can be converted to Bellows type *in the field.* Center-to-face dimensions of inlet and outlet are such that you can interchange these valves with the safety relief valves of other manufacturers. Real flexibility of application that cuts inventory costs! Optically-ground flat seating surface and fewer functional parts than comparable valves contribute greatly to easier, more economical maintenance.

Get top economy and absolute protection with Consolidated Safety Relief Valves. Full range of sizes and pressures available. Write for Catalog 1900 for complete information.

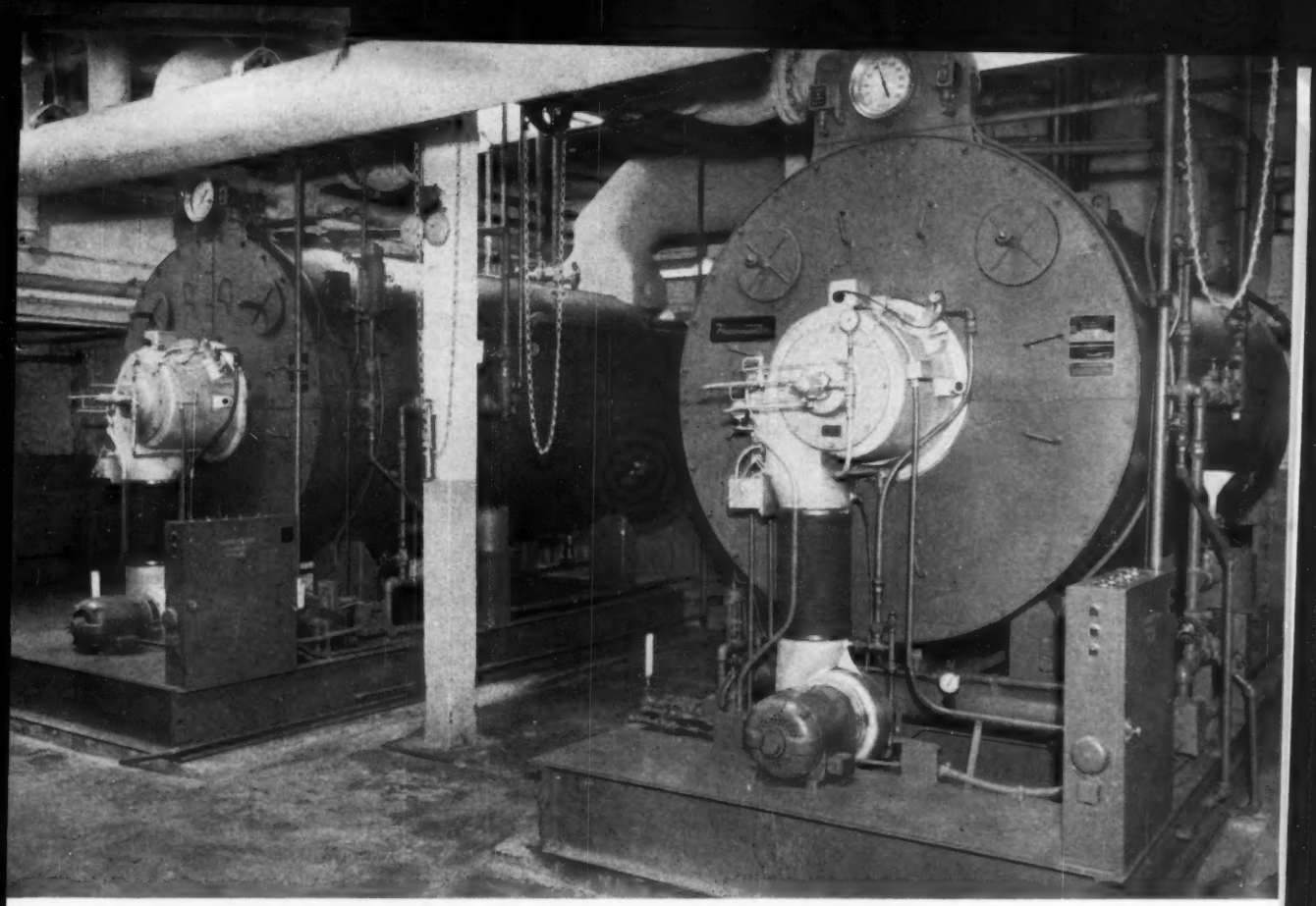
CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CONSOLIDATED SAFETY RELIEF VALVES

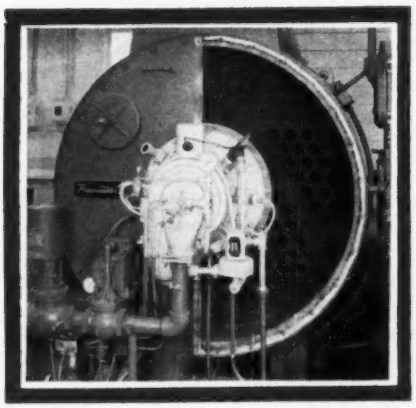
A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*



WHY TWO?

Powermaster® PACKAGED AUTOMATIC BOILERS



Time-saving inspection and cleaning of *Powermaster* is provided by easy removal of sectioned front cover without disturbing burner, accessory equipment or piping; by convenient handholes; and by easily removable rear cover. This simple and complete accessibility is a big advantage in maintaining clean, efficient operation over the entire life of *Powermaster* units.

● Major operating advantages are gained by installing two or more *Powermasters* rather than a single large boiler. These include greater assurance of a constant steam supply, increased flexibility of operation, more efficient light load standby, reserve capacity for extra-heavy load demands and for rapid expansion, greater freedom from downtime for inspection and maintenance.

Sizable cost economies also are effected because of *Powermaster's* simplified installation, space-saving compactness, automatic time-saving operation, fast steaming and quick response to load swings, high fuel economy at all loads, maintenance-saving accessibility and other service-proved features.

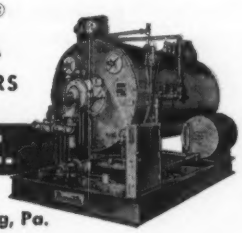
These are reasons why multiple *Powermaster* installations are now serving numerous manufacturing industries, institutions, public buildings, schools, housing projects, laundries, military posts and other steam users.

Be sure you take a close look at *Powermaster* advantages whenever you're looking for a dependable, low-cost steam supply for any plant or building requirement. Ask for Bulletin 1220.

Powermaster®

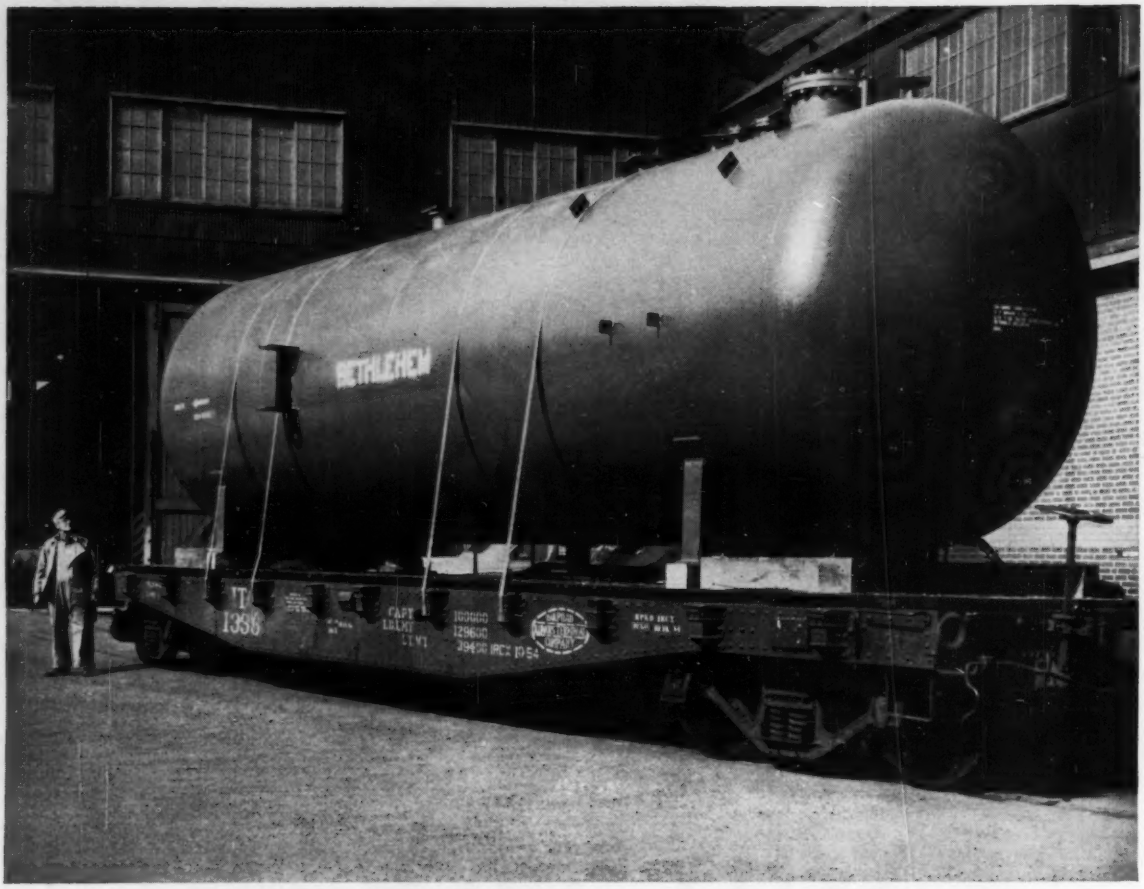
PACKAGED AUTOMATIC BOILERS

Sizes to 500 hp.; pressures to 250 psi



ORR & SEMBOWER, INC.

Established 1885 • Morgantown Road, Reading, Pa.



First of 56 vessels for Tide Water's Flying-A-Refinery in Delaware

It's big news when an oil company builds a $100,000,000-plus refinery from scratch. Tide Water Associated Oil Company is doing just that, 15 miles south of Wilmington, Del. Strategically located on the Delaware River about 50 miles downstream from Philadelphia, the new 130,000-bpd refinery will include an Orthoflow cat cracker, a fluid coker, a hydrodesulfurization unit and a sulfur recovery plant. It is expected that the refinery will begin operations late in 1956.

C. F. Braun & Co., of Alhambra, Calif., engineers and constructors for the project, chose Bethlehem to fabricate many of the vessels and tanks. The first to be completed was this 20-ton debutanizer accumulator, shown being shipped from our weldment shop in Bethlehem, Pa., late last October. Right on schedule, too.

The fifty-odd Bethlehem-built vessels include a wide range, varying in complexity from simple propane tanks to a 40-tray depropanizer. Smallest are some mixer tanks weighing only a ton or so, while other vessels tip the scales at over 100 tons, and measure well in excess of 100 ft. Diameters range from 24 in. to nearly 12 ft ID.

It takes the right equipment and the right men — experienced, well-trained men — to fill an order like this one. That's why Bethlehem got the job. And that's why, through the years, we have been chosen to fabricate many a tank and tower for chemical and petroleum processing.

We will be happy to quote on your requirements for welded tanks and vessels. Kindly call or write the nearest Bethlehem sales office for further information.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

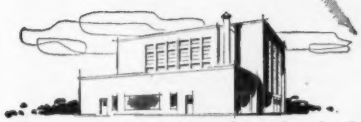
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Want to know if it can be spray dryed?





You can test your product—by the barrel or carload —in Swenson's Spray Dryer Laboratory!

Can your product be successfully spray dryed to take on a new form, get more markets, or a bigger profit potential? You can find out—*for sure!* Swenson's Spray Dryer Laboratory—the world's most advanced—at Harvey, Illinois, is devoted to answering just such questions for you.

Here Swenson engineers carefully test and analyze your product's potential in a commercial size spray dryer, matching actual production conditions. If a test quantity can pass all of the requirements here, chances are that *any quantity* can be successfully spray dryed *in your own plant.* You'll definitely know all the facts *before* major investment is required.

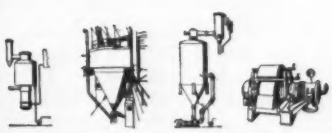
You are cordially invited to take advantage of these unique facilities. Swenson is ready to help you in every phase . . . analysis, layout, design and manufacture of equipment, and initial supervision of the job. Discuss it with Swenson now.

SWENSON EVAPORATOR CO.
15669 Lathrop Avenue, Harvey, Illinois

SWENSON

Proved Engineering for the Process Industries
Since 1889

A Division of WHITING Corporation



Evaporators • Spray Dryers • Crystallizers • Filters



JEFFREY CHAIN... A QUALITY PRODUCT

"Don't let the work-horse appearance of chain fool you", said an important buyer of power transmission equipment. "Chain is a precision product. And Jeffrey gives us that precision."

In the manufacture of Jeffrey Chain and Sprockets, metals get prime consideration; steel, bronze, malleable iron and stainless are carefully selected for each chain and sprocket requirement. Machining, heat treatment, assembly and inspection are accurately controlled to insure that these products meet Jeffrey's high quality standards.

Jeffrey Chain is designed for maximum strength with minimum weight. Jeffrey Sprockets and Chain make an excellent combination, giving full bearing contact without play or binding. They assure most efficient use of power and long life for power transmission and conveying equipment.

Chain engineers in Jeffrey district offices are on call to help you specify this quality chain which is normally available from distributor or factory stocks. For further information, write to The Jeffrey Manufacturing Co., Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT • TRANSMISSION MACHINERY • CONTRACT MANUFACTURING

Lapp introduces the "MICROFLO" PULSAFEEDER

A CONTROLLED-VOLUME PUMP FOR PRECISION PUMPING AT MICRO-FLOW RATES



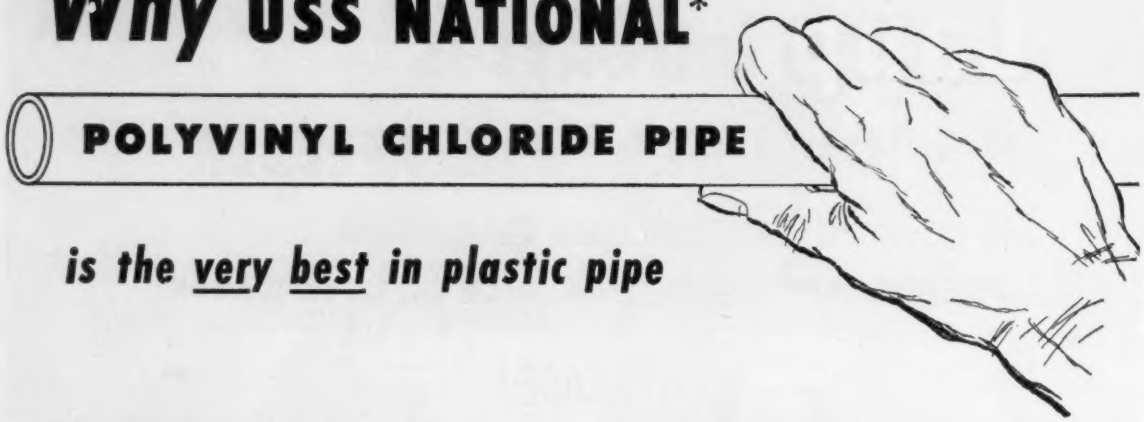
Now, a controlled-volume proportioning pump for laboratory application, pilot plants, and industrial production, where requirements are for pumping of precise volumes at micro-flow rates without risk of leakage or contamination of fluid being pumped. The "Microflo" Pulsafeeder combines the best features of both piston and diaphragm pumps by using a piston for constant volume measuring purposes and a diaphragm to seal the product pumped against leakage or contamination. All liquid handling parts have been selected for their resistance to corrosion. Maximum pumping capacity is 2150 ML. per hour, maximum discharge pressure 1000 psig. Pumping rate of the "Microflo" Pulsafeeder can be manually adjusted while the pump is idle or operating, or if desired, complete operation can be governed by automatic controls.

Lapp

WRITE

for Bulletin 500 which contains complete information and specifications on the new "Microflo" Pulsafeeder. Lapp Insulator Co., Inc., Process Equipment Division, 504 Wilson St., LeRoy, N. Y.

Why USS NATIONAL* POLYVINYL CHLORIDE PIPE



is the very best in plastic pipe

JUST as Stainless Steel is the absolute ultimate in metal pipe and tubing, so is Polyvinyl Chloride the unparalleled material for plastic pipe.

National Polyvinyl Chloride Plastic Pipe is not a "substitute" material—it's a high quality unplasticized-rigid pipe, specifically designed for applications where it will do a *better* job than any other material.

Two types of extruded National Polyvinyl Chloride Plastic Pipe are available in sizes ½" to 6" inclusive and in Schedules 40 and 80.

NORMAL-IMPACT—for installations requiring the highest chemical resistance attainable, together with high strength and excellent creep resistance.

HIGH-IMPACT—for installations requiring excellent chemical resistance and a high degree of toughness even at low temperatures.

*Trademark



The following properties are shared by both Normal- and High-Impact National Polyvinyl Chloride Plastic Pipe:

Chemical Resistance—resists attack by acids, alkalies, salt solutions, and alcohols, as well as many other types of chemicals. Nontoxic. Will not impart tastes or odors to liquids.

Rigidity—permits use in overhead piping installations with pipe supports. Schedule 80 pipe may be threaded with steel threading dies.

Light Weight—Twenty feet of 2-inch Schedule 40 pipe weighs less than 13 pounds. Easier to install in cramped quarters and hard-to-reach places.

Weather Resistance—resists deterioration due to aging when exposed to direct sunlight, plus resisting fungi, bacterial action and soils.

Ease of Installation—fittings readily attached by either (1) solvent cementing, (2) threading, (3) heat welding, (4) adhesives.

Smooth Internal Surface—results in low flow resistance, minimizes the build-up of deposits.

For the full story on USS National Polyvinyl Chloride Plastic Pipe, send for Bulletin 24. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

NATIONAL *plastic* PIPE

UNITED STATES STEEL

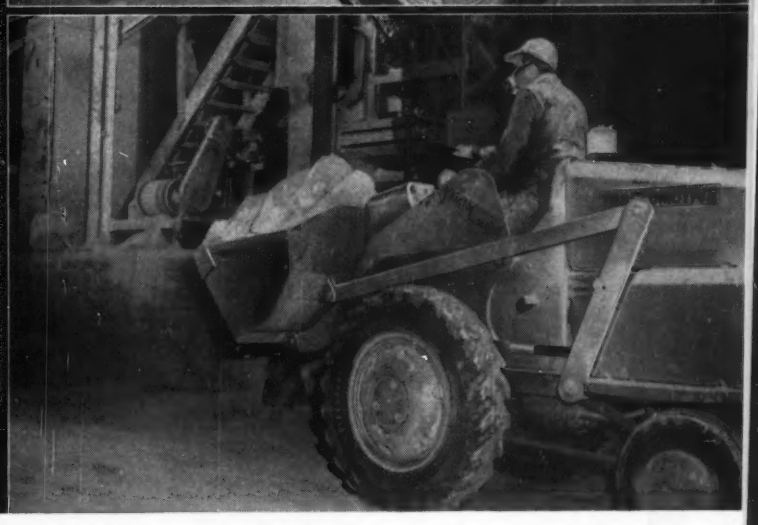
easy

TO GET A FULL LOAD



easy

TO DELIVER A FULL LOAD



with compact

TRACTOMOTIVE TL-6 TRACTO LOADER—

a high producer in confined areas

No ramming into pile to fill the half-yard bucket of the TL-6 Tracto-Loader. Operator lets the hydraulic torque converter do the crowding — smoothly, steadily . . . and there's a scooping action, too, with the tip-back bucket. You get a heaping load before the booms are halfway up.

On the go, the bucket holds the *full load* . . . has a 50-degree tip-back at only 3 feet above floor — means easier maneuvering, greater stability, better visibility.

Operator has an easy time handling the TL-6. No gear shifting — he just pulls or pushes a lever to change direction. Short, 6½-foot turning radius and over-all compact design make it easy to unload box-cars or travel through narrow aisles and doorways, make hairpin turns near columns and posts.

See the TL-6 in action. Let us make an appointment for you with your Allis-Chalmers Construction Machinery Dealer for a demonstration. Send coupon NOW.



Send For Free Descriptive Catalog
On The Complete Line Of Tracto-Loaders

TRACTOMOTIVE

TRACTOMOTIVE CORPORATION, DEERFIELD, ILLINOIS

TRACTOMOTIVE CORPORATION, Dept. CN
Deerfield, Illinois

☐ Please arrange a demonstration of the TL-6
☐ Send catalog on Tracto-Loaders

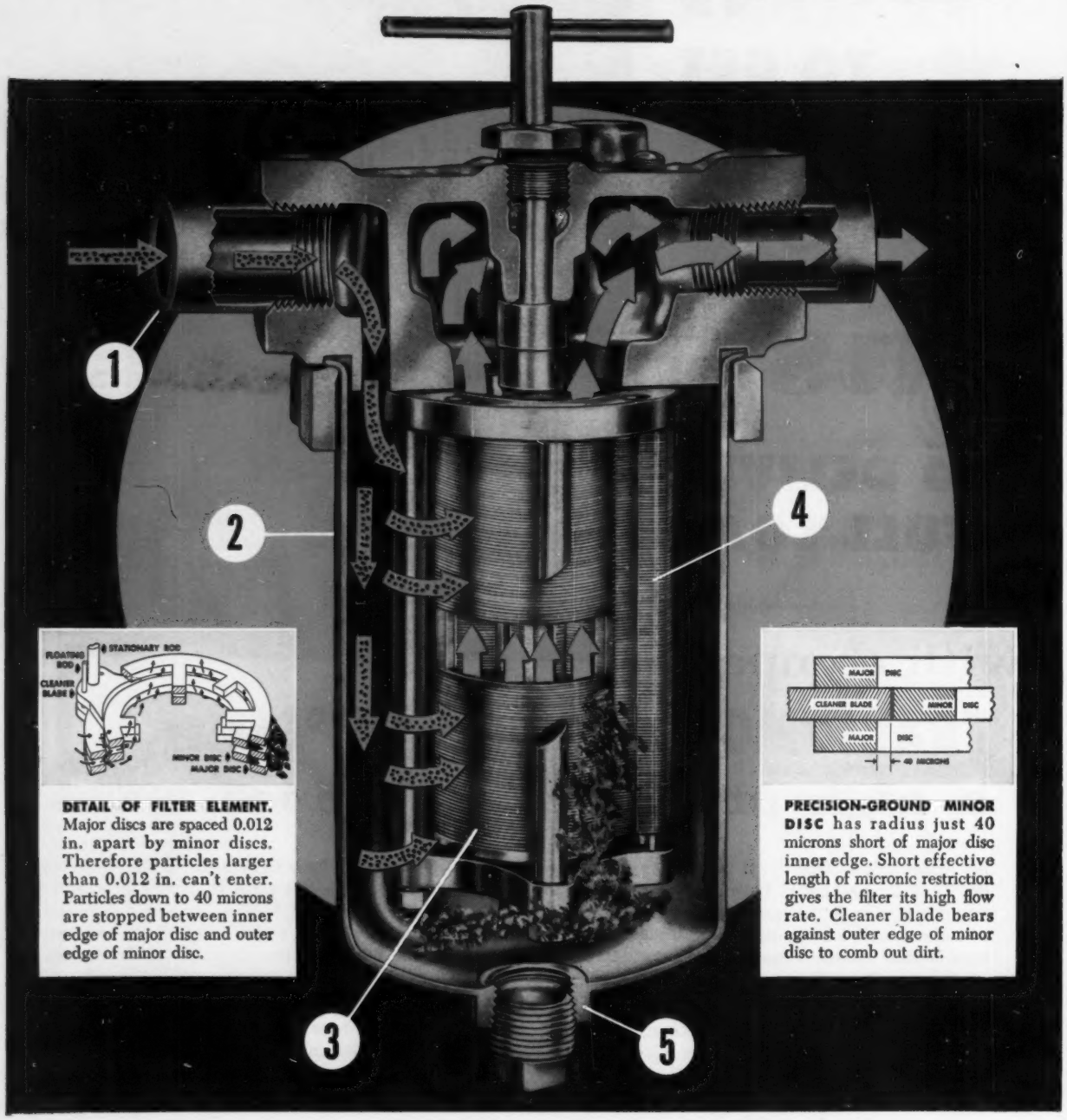
NAME ..... TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... STATE .....

New! CUNO 40-micron



DETAIL OF FILTER ELEMENT. Major discs are spaced 0.012 in. apart by minor discs. Therefore particles larger than 0.012 in. can't enter. Particles down to 40 microns are stopped between inner edge of major disc and outer edge of minor disc.

PRECISION-GROUND MINOR DISC has radius just 40 microns short of major disc inner edge. Short effective length of micronic restriction gives the filter its high flow rate. Cleaner blade bears against outer edge of minor disc to comb out dirt.

CUTAWAY of new SUPER Auto-Klean. Dirty liquid enters inlet (1) at left, fills housing (2) and flows through metal-edge filter (3) of stacked major and minor discs. Trapped dirt is combed out by cleaner blades (4) when discs are rotated and is removed through drain (5). Clean liquid rises through center of filter element, leaves at right.

self-cleaning filter!

The SUPER Auto-Klean

FOR PROCESS LIQUIDS

. . . and you can clean this filter by simply turning the handle!

Many times smaller than other micronic filters of equal capacity, Cuno's new SUPER Auto-Klean filter now makes possible economical, compact, micronic filtration at high flow rates and eliminates the need for replacement cartridges. Here's what SUPER Auto-Klean offers the process industries:

1. Micronic filtration with a self-cleaning filter. Filter can be cleaned continuously with motor drive or intermittently by manually turning handle.

2. Eliminates cartridge changes. Ends operating costs if you've been using cartridge filters.

3. No pressure drop build-up. An 8-in. long, 2¾-in. diameter cartridge handles 30 gpm of liquid at 50 centipoise viscosity with only 3 psi pressure drop—up to 75% more with slightly higher pressure drop.

4. Positive protection against particles larger than 40 microns (actually 0.0015-in.). Filter can't rupture or channel.

5. Much smaller than replaceable-cartridge-type filters of equal capacity, you save on lower initial costs, lower installation costs, lower space requirements than for cartridge units. You get high capacity in a small package.

6. No duplex units needed. Handles full flow all the time with no interruptions for cleaning.

7. SUPER Auto-Klean fits existing Auto-Klean housings. You can easily replace most 2¾-in. diameter cartridges with SUPER Auto-Klean for finer filtration.

8. SUPER Auto-Klean is available in all-steel or type-316-stainless-steel construction with Teflon seal.

Typical SUPER Auto-Klean installations

1. 50 gpm of organic solution, viscosity 100 to 130 cps at 80°C operating temperature and 125 psi operating pressure—40-micron filtration.
2. 1.2 gpm of polyethylene, viscosity 50,000 cps at 340°F, operating pressure of 2,000 psi and pressure drop of 800 to 900 psi—40-micron filtration.
3. 10 gpm of resin, 2,000 SSU at 500°F and 100 psi operating pressure—40 micron filtration.
4. 10 gpm of printing ink—40 micron filtration.
5. 20 gpm of coating liquid—40 micron filtration.
6. Phenolic water at 125 psi operating pressure on pumps—40 micron filtration.
7. 150 gpm of wax—40 micron filtration.

CUNO

ENGINEERED FILTRATION

Removes More Sizes of Solids from More Kinds of Fluids
AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

MAIL COUPON FOR COMPLETE INFORMATION

- ☐ Absorption oils
- ☐ Acids
- ☐ Alkali
- ☐ Casein
- ☐ Cellulose acetate
- ☐ Chlorinated solvents
- ☐ Cleaning solutions
- ☐ Coal tar solvents
- ☐ Coatings
- ☐ Enamels
- ☐ Ethylene Glycol
- ☐ Ethyl and methyl cellulose
- ☐ Fuel tar
- ☐ Gasoline
- ☐ Glacial acetic acid
- ☐ Grease
- ☐ Industrial alcohols
- ☐ Japan
- ☐ Lacquers
- ☐ Nitrocellulose Solutions
- ☐ Nitrogen
- ☐ Paint
- ☐ Paraffin
- ☐ Petroleum solvents
- ☐ Photographic developing solutions
- ☐ Pickling brines
- ☐ Pyroxylin
- ☐ Resins
- ☐ Rust proofing compounds
- ☐ Sizing
- ☐ Solvents
- ☐ Tar
- ☐ Varnishes
- ☐ Water and water solutions
- ☐ Wax
- ☐ Other _____

CUNO ENGINEERING CORPORATION
3-3 South Vine Street, Meriden, Conn.

Please send me full data on the NEW Cuno SUPER Auto-Klean filter.

Name_____

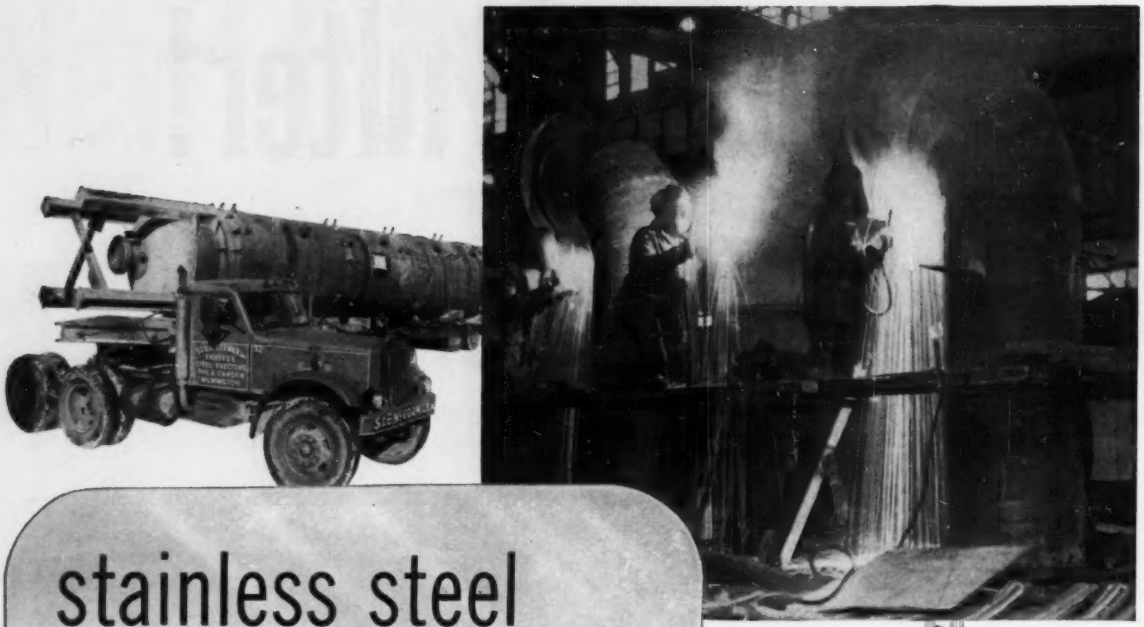
Firm_____

Position_____

Address_____

City_____ Zone____ State_____

5.8



stainless steel holds the answers

Every industry that works with steel has its special problems of the proper steels for every job . . . more and more industries are finding that Stainless "holds the answers" to their problems.

Take the petroleum and chemical industries for instance. They demand resistance to corrosion, to abrasion, high temperatures, cold temperatures, scaling and hydrogen blistering. Solid stainless can do the job. But, in some equipment, stainless cladding can answer the problems . . . and cut costs as well.

Sun Ship knows how to fabricate stainless and the other special alloys. They have the facilities and experience. Large jobs or small jobs will receive prompt attention.

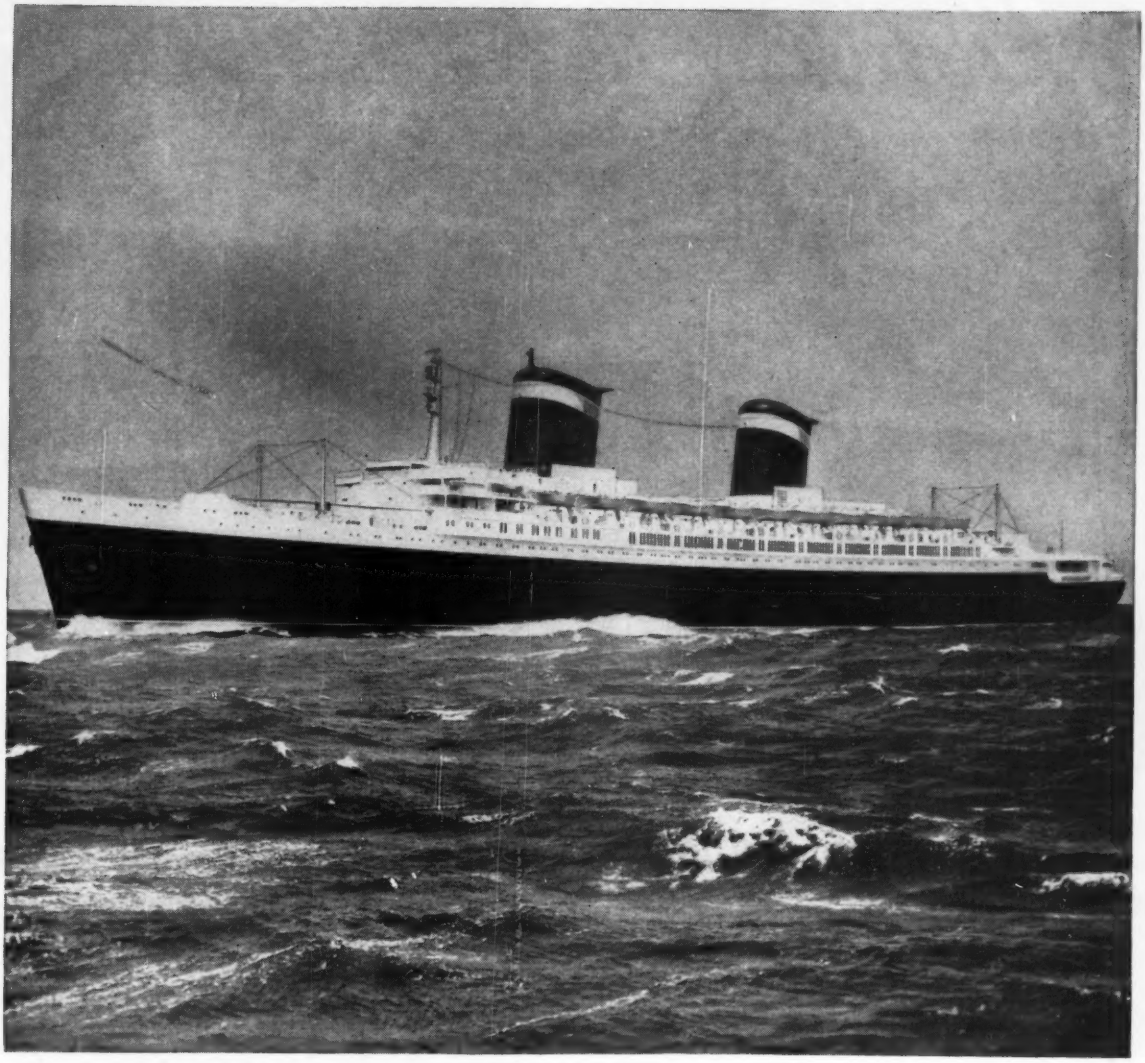


Our Sales Engineering Department will be glad to discuss with you any problems to which our Alloy Products Shop may hold the efficient and economical answer.

ALLOY PRODUCTS SHOP

OF Sun SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • CHESTER, PA. • 25 BROADWAY, NEW YORK CITY



S. S. UNITED STATES, pride of the United States Merchant Marine, is the world's most modern superliner.

LEADERSHIP GOING PLACES!

Fastest passenger vessel in the world, the S. S. United States has built a reputation for outstanding performance. Esso Petroleum Solvents have the same fine reputation in industry, achieved through product character and quality. Next time you order, specify products backed by years of continuing research and constant product improvement – Esso Petroleum Solvents.
For information or technical assistance, call your local Esso office or write Esso Standard Oil Company, Solvents Division, 15 W. 51st St., New York 19, N. Y.

ESSO
PETROLEUM SOLVENTS

RESEARCH AND EXPERIENCE DEVELOPED THE FINE CHARACTER OF ESSO SOLVENTS

Change motors in minutes—

with FALK *all-steel* MOTOREDUCERS



No long and costly "down time" involved

Motors can be interchanged or replaced *in minutes* with the all-steel, All-Motor type FALK Motoreducer. No long and costly "down time" is involved in making the change!

Best of all, replacement is not limited to original make of motor—new NEMA frames may be substituted for old. This versatile Motoreducer operates with any make, speed or type of standard foot-mounted motor within its AGMA rating. No modification, no special shaft, no "partial" motor required.

In addition to unmatched motor interchangeability, this dependable gear drive—the "work horse of industry"—offers: widest choice of output-shaft position (horizontal, vertical, right-angle)...any output-shaft connection...any mounting, including wall and ceiling...standard speed range from 1.5 rpm to 1430 rpm. All these advantages, plus proved efficiency, low maintenance and extra-long life, make the All-Motor type FALK Motoreducer your best buy for any job requirement.

Furnished in sizes up to 75 hp with any make, style or type of motor; or, *without a motor if desired.* FALK Motoreducers are available from convenient factory, field or distributor stocks, from coast to coast.

Write for Bulletin 3100

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

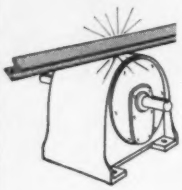
MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

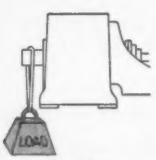
FALK

...a good name in industry

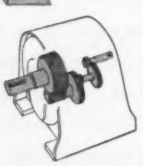
FALK "IN-BUILT" FACTORS assure full dependability—better service—longer life



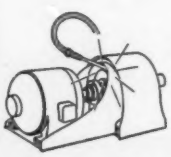
ALL-STEEL HOUSINGS
Rugged, strong, rigid ...all parts heavy steel plate, formed and welded in the Falk Weld Shop.



LARGE OVERHUNG LOAD CAPACITY
Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum loads.



PRECISION GEARING
Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion.



SEALED HOUSINGS
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CITRIC ACID. An important chemical in many metal cleaning pastes and liquid formulations for both home and industrial use. Solutions of citric acid, partially neutralized with ammonia, are excellent rust and scale removers. Their use results in the least possible loss of metal. Moreover, citric acid has an extremely low order of toxicity.

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#61, Chemicals for Metal Finishing . . . . . ☐
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PROCESS EQUIPMENT DIVISION

118-D

Chementator

H. T. SHARP

√ **Standard Oil (Ind.) is developing a new low pressure polyethylene process. First material made is said to be 2-5 times as stiff as other varieties and usable at over 212 F. No production plans have been set.**

√ **It's almost definite that a major oil firm will soon build or help underwrite a nuclear reactor. A growing need for gross fission products is reported to lie behind the move.**

√ **Powder melt techniques, used to form synthetic sapphires, have been successfully adapted to making high-temperature silicon transistors. They thwart contamination by traces of dissolved oxygen, a cause of failures.**

New plant to make nylon from castor oil

A new plant to make a type of nylon fiber from castor oil is now being built at Sao Paulo, Brazil. Backing the venture are Brazilian interests and Organico, a partially-owned subsidiary of France's Pechiney.

Monomer, polymer and fiber will all be made by the Rilsan process. This involves esterifying ricinoleic acid which is separated from the oil and cracking the ester to undecylenic acid and heptaldehyde. The acid is then used to make the fiber, nylon 11.

Since Brazil is one of the world's top producers of castor beans, making nylon by this route would be especially attractive.

Reports of another new fiber based on castor oil come from Japan. Researchers at Kyushu University say a newly-made synthetic—based on castor oil, coal and petroleum—is lighter than nylon, easier to dye and more resistant to heat.

Getting set for polypropylene rush

With nearly every major chemical company working on it, polypropylene looms as the next "big" plastic for film and fiber use. High molecular weight (over 100,000) varieties are being made in both Italy and Germany and people who've seen samples are impressed by their relatively high melting point (around 150 C.) and resistance to solvents.

Based largely on Carl Ziegler's work on ethylene polymerization (*Chementator*, Jan. 1956, p. 104) and working under a grant from Italy's Montecatini, intensive polypropylene research has been carried on at Milan Polytechnic Institute by Julio Natta.

Natta developed a series of metal alkyl-metal halide complexes which catalyze the polymerization reaction to produce a crystalline structure with a spiral configuration. The reaction, like Ziegler's, is said to occur at low temperatures and pressures and the technique can be applied to make other polymers, i.e. polystyrene.

Prompted by the availability and low cost of propylene, other Ziegler licensees throughout the world are also working on the polymer. The German mining firm, Hibernia, is running a 1 ton/day (design capacity) pilot plant. And other firms on the continent appear to use know-how developed by Natta.

Montecatini is reported to have an agreement with Ziegler and will license the Natta-developed process once patents are granted. The firm is already being swamped by potential licensees.

The Phillips low pressure polyethylene process (*Chementator*, June 1955, p. 103) has also been tried on polypropylene.

In its Belgium patent (530,617) on the process, Phillips reports a polypropylene with a molecular weight over 50,000. Modifications of the chrome oxide-catalyzed reaction described in the patent are said to have boosted this considerably. In addition, Phillips is working on a copolymer of propylene and ethylene. And, significantly, M. W. Kellogg mentions "a whole new spectrum of resins from olefins" in announcing that it is the fourth Phillips process licensee.

But excitement over polypropylene is said to be tempered a bit by its reported susceptibility to oxidation and yellowing. Much of today's experimentation aims at developing an inhibitor which will make the new material more stable.

Aspeco process to be tried on shale oil

The Swedish-developed Aspeco process will be used to process Colorado oil shale in a $250,000 pilot plant to be built by Denver Research Institute for Oil Shale Corp., Beverly Hills, Calif.

Due to be completed in April, the 2 ton/hr. unit will first process shale, then its sponsors expect to open the plant to others, who may test the method on either shale or other materials. A try at using the plant to roast low-grade iron ore is likely, especially if small-scale tests now being run by M. A. Hanna Co. prove encouraging.

Oil and chemical companies' interest in the process is sparked by the advantages claimed:

- Low water use—needed only in final condensers.
- No contamination of oil or byproduct fuel gas by exhaust gases or nitrogen—there is no combustion in the retort.

Developed by the Stockholm engineering firm Aspegren & Co., the Aspeco process feeds crushed shale to a horizontal, rotary kiln. Steel balls, preheated to 1,000 F., enter at the opposite end to heat and further crush the shale. Volatiles vaporize, pass out of the kiln and go directly to cracking units.

Spent shale, coated with small amounts of carbon residue, passes to one end of a second horizontal, rotary kiln. The now-cool steel balls and preheated air enter at the other end. Carbon residue burns, reheating the balls to shale pyrolysis temperature.

In addition to pinning down cost factors the pilot unit will explore such process variations as using balls made of spent shale instead of steel.

Planning a "first" in coal carbonization

Pittsburgh Consolidation Coal Co. may soon start work on this country's first commercial fluidized-bed, low-temperature coal carbonization plant. To be built at Cresap, W. Va., the plant's output of char would be burned by Ohio Power Co. to produce power for Olin Mathieson's newly announced aluminum plant at Clarington, Ohio.

Final decision on size and scope of the carbonization plant will probably be postponed until development work on the coal mine and power plant, planned for nearby sites, is further along. Meanwhile, Pitt Consol is seeking outlets for the tar produced in carbonization. Present plans call for mining 2 million tons/yr. of coal. If all this is sent through the carbonization plant, some 1.5 million tons of char and 60 million gal. of tar will be made. And that's a lot of tar to dispose of profitably.

Some 6 to 7% of this is cresylic acid. Separating this and extracting other usable chemicals is a problem in process economics. Three disposal schemes are being considered:

- No upgrading—burning as fuel or selling for road tar.
- Partial upgrading—making carbon black or electrode-grade carbon for aluminum plant use.
- Full upgrading—extracting usable chemicals to make plasticizers and plastics.

The last alternative looms as the most profitable, and it's likely that Olin will join in the work on upgrading. Olin now participates in Battelle's work on upgrading lignite tar.

(Continued on page 108)





Pssst! Have you heard?
KINNEY can handle condensable vapors!

IN FACT, Kinney offers more devices to counteract the presence of excessive condensable vapors in vacuum systems than anyone else. The pumping effectiveness of mechanical vacuum pumps . . . in research and industrial applications . . . depends upon the complexity of the contamination problem and the means selected to eliminate it. Since there is no one cure-all solution to contaminating vapors which vary in quantity and type, and with operating conditions (pressure, temperature, time, etc.), Kinney offers several methods, which singly or in combinations, assure maximum pump efficiency.

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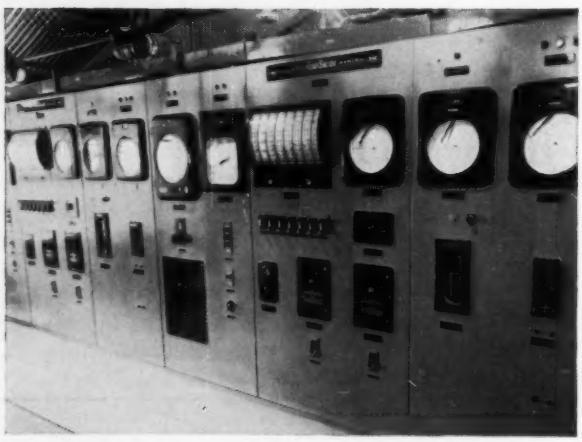
Aerial view of acid section at Weed Heights, Nevada. FluoSolids System is in foreground . . . contact acid plant in right rear.

Fluidization

NEW TOOL FOR THE PROCESS INDUSTRIES

You've heard a lot about fluidization in the last ten years and the changes it has brought about in the petroleum industry. But did you know that new applications for fluid bed techniques are still turning up in many non-catalytic fields as well? A good case in point is the installation shown on these pages.

Anaconda First to Roast Low Grade Sulfur

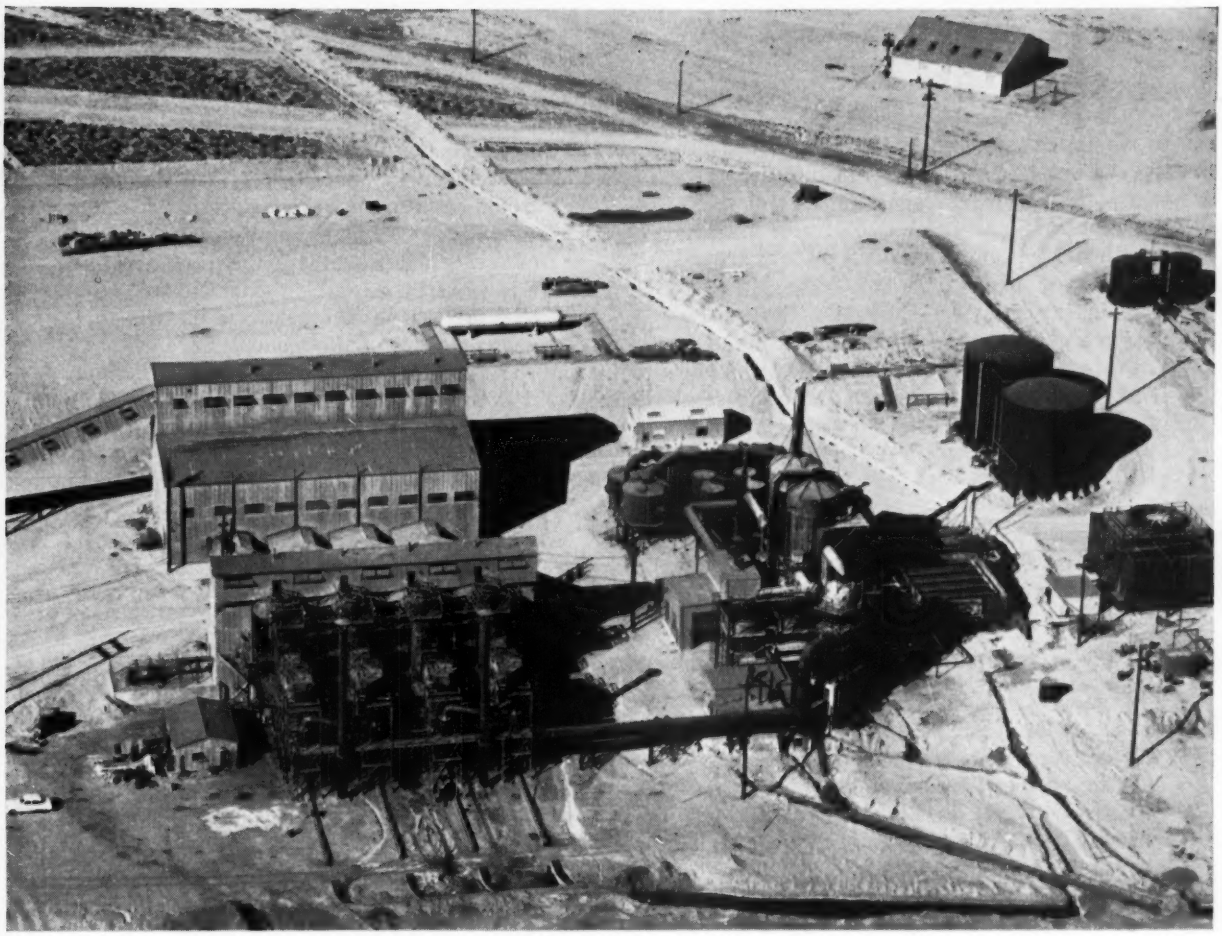


This completely instrumented FluoSolids control panel gives a graphic picture of the entire operation.

The world's first commercial installation for producing SO_2 gas from low grade sulfur ore is now on stream at Anaconda Copper Company's plant at Weed Heights, Nevada.

The FluoSolids System that makes this possible includes four 18 ft. dia. Reactors plus other Dorr-Oliver equipment and auxiliaries. SO_2 gas is sent to a 450 TPD contact acid plant which supplies all acid requirements for leaching 11,000 tons of copper ore per day.

Feed to the system is 650 to 750 tons per day and gas production 26,000 to 30,000 C.F.M. Gas strength averages 8 to 12% representing a sulfur recovery of 98%. Unusual? Yes, because this is the first time that low



Ore to Produce SO_2 for Acid Manufacture

grade sulfur ore could be recovered as SO_2 . . . economically. Here's how the system works . . . ore averaging 28% total sulfur is crushed to 10 mesh and fed dry to the Reactors which operate in parallel. Once ignition temperature is reached no extraneous fuel is needed. Ore is simply fed in at the design rate, latent heat in the bed immediately brings it to ignition temperature, and the fluidizing air oxidizes the sulfur to SO_2. Shutting down is a matter of minutes. And because the fluid bed stores sufficient heat, roasting can be started again after as much as 72 hours without adding additional fuel.

For Further Information – Chances are you don't need 450 tons of sulfuric acid a day. But if there's a step in your flowsheet where intimate contact between solids and gases is essential, fluidization should be investigated. As licensee in all non-catalytic, non-hydrocarbon fields, Dorr-Oliver has continually expanded the applications of this new technique since 1944. We will be glad to work with your research and development department, run pilot plant tests at our Westport Laboratories, or cooperate in any other way necessary to insure a realistic evaluation of fluidization in terms of your process. Just drop a line to Dorr-Oliver Incorporated, Stamford, Conn., or in Canada, 26 St. Clair Ave. East, Toronto 5. No obligation of course.

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Solving this may lead Pitt Consol to supply the power plant entirely with char so as to maximize tar output. Pitt Consol will use its own fluidized-bed process in the carbonization plant. In pilot stages for several years, the process takes crushed coal and fluidizes it with air. Carbonization takes place at around 900 F.

Melting of some of the coal, with resulting agglomeration in the bed, is a major difficulty of the process. Pitt Consol hasn't yet said how it's been solved, but pre-oxidation of the coal is a likely solution. And recycling hot char has been successful in other experimental plants.

New metal plating processes tried

Putting new life into the long discarded gas plating process, Commonwealth Engineering Co., Dayton, Ohio, has developed a method of depositing a metal coating on materials of all types and shapes. The process is reported to be running on a commercial scale.

The deposited layer is tough and adherent, and the process has successfully plated such diverse materials as tungsten carbide, uranium and stainless steel on other metals and alloys, plastics, fibers, papers, etc.

Commonwealth's revived process works like this: An organo-metallic compound (i.e. nickel carbonyl) is vaporized, picked up by an inert gas carrier and passed into the plating chamber through jets aimed at the object to be plated.

Heating the object above the decomposition temperature of the metal compound breaks the compound down when it contacts the object, depositing the metal.

The Army Chemical Center, Edgewood, Md., ran the process on a pilot plant scale for several months last year. Results are termed highly satisfactory. But operation was stopped when the Center discovered a new, and now classified, process which it claims is simpler and cheaper to run.

Starting up new vinyl acetate plant

Shakedown runs are now under way at Air Reduction Chemical Co.'s new vinyl acetate monomer plant at Calvert City. Set for full scale production in April, the 30 million lb./yr. unit will use a process developed by Wacker-Chemie and Farbwerke Hoechst in Germany.

The Airco plant is only one of several current additions to vinyl acetate capacity.

- Celanese doubled its Pampa, Tex., facilities last December.
- Carbide and Carbon is now boosting capacity at its Texas City plant by over 100%.
- DuPont, which produces for captive use, is in the throes of a $2 million expansion.

Except for Celanese, which uses its own process, U. S. makers of the monomer are believed to use similar processes. Airco, for example, will take acetylene, remove traces of sulfur and phosphorus and mix it with dry, recycle acetylene and varporized acetic acid. Heating the mixture to 340-400 F. and passing it over zinc-based catalyst forms the monomer.

Circulating a heat transfer fluid through the reactor is necessary since the reaction is highly exothermic.

After cooling and condensing reaction products, still-gaseous excess acetylene is recycled. High-purity acetic acid is recovered by continuous fractional distillation and recycled. Fractionation also removes other impurities from the monomer product.

Celanese, on the other hand, starts with acetaldehyde and acetic anhydride made in adjacent plants. These form ethylidene diacetate from which the company gets acetic acid and vinyl acetate.

New fertilizer process sparks expansion

Complete success of a four-month "crash" research program underlies the $4 million expansion program recently announced for International Minerals and Chemical Corp.'s Bonnie plant near Barstow, Fla. The plant makes both triple superphosphate, a fertilizer, and dicalcium phosphate, a feed supplement.

The stepped up research activity resulted in a switch in processing steps and the development of a novel submerged combustion unit. The former enabled IMC to make two high-quality products at the same time instead of alternately, a severe limitation of the earlier process. The new submerged combustion unit cut costs and saved time in the important acid-concentrating step.

Originally, IMC treated entering phosphate rock with phosphoric acid. Now, low grade (68% bone phosphate of lime) rock is digested with sulfuric acid, resulting in weak phosphoric acid and gypsum. The gypsum is

(Continued on page 110)



MORE GENERAL CHEMICAL "ALUM"

for America's Paper and Water Industries!

Announcing a New Liquid Alum Plant at Hopewell, Va.

A 25th plant is now being added to General Chemical's coast-to-coast network of aluminum sulfate production centers! The new liquid alum plant at Hopewell, Va. will serve paper mills and water and sewage treatment plants in that part of the country . . . just as General's other facilities provide for needs of consumers near them.

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General Chemical dry and liquid aluminum sulfate has long been the first choice of industrial and municipal users everywhere. They have found they can always count on General Chemical for the right grades made to their requirements, with the same uniform high quality lot after lot.

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This is a combination that can't be beat. That is why it is *good business to do business with General* for alum or any of the other basic chemicals listed below.

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CHEMICAL PROGRESS WEEK-APRIL 23-28

filtered out and the weak acid sent to IMC's uranium plant for uranium removal (*Chem. Eng.*, June 1954, p. 118).

When it returns, the weak acid is concentrated to about 54% P_2O_5 by the submerged combustion units. Five of these stand in a large tank of acid. Fired with Bunker C fuel oil, a novel feature, they provide direct heat transfer to the acid.

Some concentrated acid then reacts with high grade (77% b.p.l.) rock to make the triple superphosphate, while the rest is defluorinated and reacted with limestone to make the dical.

Where the original plant made 112,000 tons/yr. of both products, the expansion will enable it to turn out from 375,000 to 475,000 tons/yr. of the fertilizer and 60,000 to 100,000 tons/yr. of the feed supplement.

Processing low grade ore to titanium

Industry men are closely watching current Bureau of Mines titanium projects. They speculate that methods now being developed could be strung together into a new three-step, integrated process for getting high purity metal from plentiful illmenite ore.

Use of illmenite has been limited by its high iron content and the Bureau is now working on two ways to overcome this:

- Smelting projects at Albany, Ore., have made high grade (greater than 80% TiO_2) slag and pig iron from domestic ores. Chlorination tests on this slag will soon be run at the Bureau's Boulder City, Nev., station.
- Reducing and chlorinating projects now underway at Boulder City reduce illmenite with petroleum coke at about 2,600 F. This yields a mixture of acid-soluble iron, titanium carbide and sub-oxides of titanium (Ti_2O_3 and TiO). The iron is leached out and the titanium compounds are chlorinated at 750-840 F.—instead of the 1,470-1,650 F. needed with TiO_2—to recover over 90% of the titanium.

Another Boulder City project makes very pure and ductile titanium metal via a two-stage sodium reduction of chlorides.

In the first stage of the pilot plant, reduction at 1,100-1,200 F. results in a mixture of titanous chloride and sodium chloride. More sodium is added in the second stage and the subvalent titanium is reduced to the metal—in the form of needles and crystals having a Brinell hardness of less than 100.

The Bureau is also reported to be working on a low temperature (300 F.) technique similar to National Distillers high surface sodium dispersion method now used in other fields.

In addition, Boulder City engineers are piloting an electrorefining process that reclaims high quality metal from offgrade sponge and certain alloys. A fused salt electrolytic cell, working under an inert atmosphere, deposits pure titanium metal at the cathode and impurities as anode sludge.

Industry people visualize an integrated process that would start with illmenite, remove iron and chlorinate the titanium, reduce chlorides with sodium and produce high quality metal by electrolysis. Aside from use of a cheap, plentiful raw material, main advantage of such a process would be its low-temperature operation—thus easing chloride handling and corrosion problems.

Hiring the handicapped—processwise

Despite its major limitation—a product acid only 40% concentration—an autoxidation process will be used in a new British plant to recover sulfuric acid and ferric oxide from waste pickle liquor.

Designed jointly by the British Iron and Steel Research Association, The Steel Co. of Wales and Sieman Carves, Ltd., the new plant will be based on five years of pilot plant work on process development. The process takes the waste liquor, crystallizes the ferrous sulfate and roasts the crystals at 1,500 to 1,600 F. to decompose them to ferric oxide and sulfur dioxide, with about 10% sulfur trioxide.

Before going to the autoxidation tower, the gases are scrubbed and compressed. In the tower, a manganese sulfate catalyst is said to promote reaction of the SO_2 with ozone and water to form sulfuric acid.

Costs of similar processes and the low concentration of this acid have previously discouraged this approach—steel men preferring simply to neutralize the waste liquor and dump it. These factors have also stirred interest in processes, like the Ruthner process (*Chementator*, Jan. 1956, p. 108), which takes a different approach.

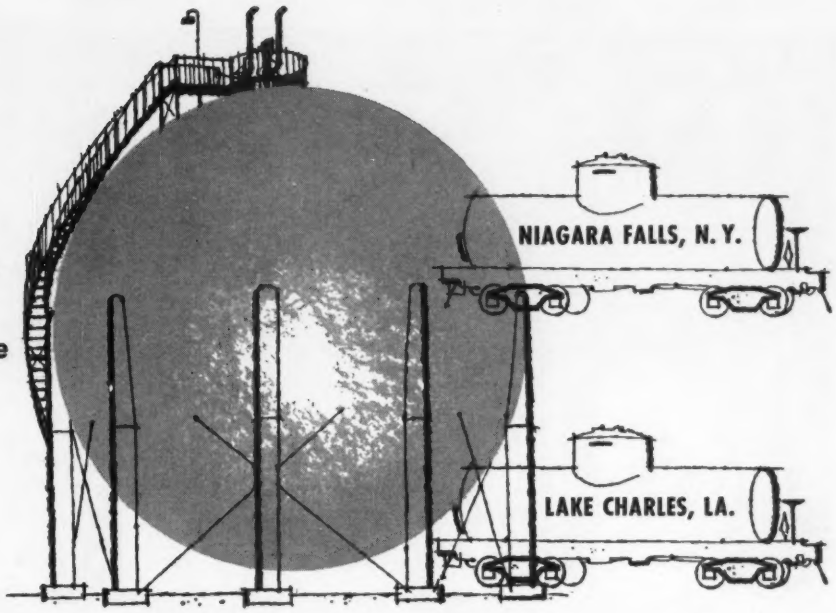
However, knowing that 40% acid is more than adequate for pickling use, and backed by pilot plant results, the British groups feel that they can eliminate the bugs which have plagued similar ventures and make the process pay in full scale operation.

For more of WHAT'S HAPPENING . . . 113

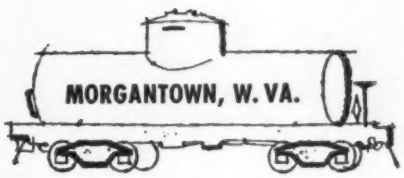
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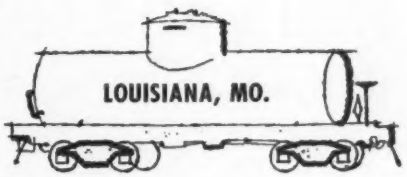


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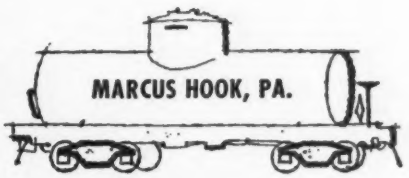
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Talk over your ammonia requirements with an Olin Mathieson representative soon. Let him show you why more people buy more chemicals to better advantage from Olin Mathieson . . . America's prime producer of basic industrial chemicals.

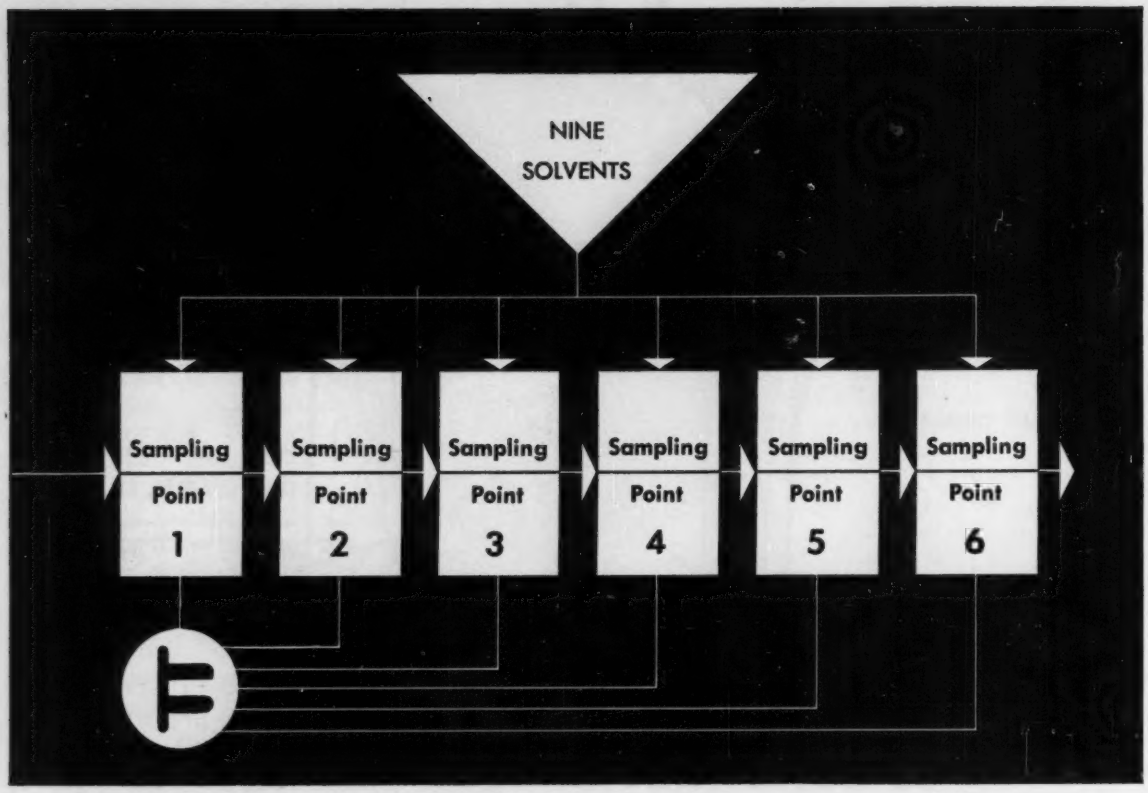


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Delays in detecting LEL reduced

In a process using nine solvents with lower explosive limits ranging from 1.3% to 13%, a P-E TRI-NON* Infrared Analyzer has the job of reporting vapor concentrations continuously so they can be kept below 80% of the explosive limit.

The TRI-NON analyzer is sensitized to give an equal and linear response for each of the nine solvents. This linearity allows summation of the various combinations at each station regardless of the actual vapor concentration of any one component. Only an infrared analyzer using a selective detector can be sensitized in this manner.

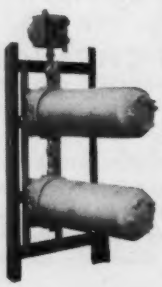
One TRI-NON analyzes samples from six different points in succession along the process line at a speed of 30 seconds per point. Each point is checked every 3 minutes – often enough in this particular application to detect any dangerous change in vapor concentration. (Instrument response times up to 3.4 seconds for 98% of final value are standard.) The TRI-NON is the only infrared analyzer with sufficient speed and stability to cover so many sampling points safely.

In combustible vapor analysis, whether the system contains one or a mixture of solvents, the TRI-NON provides the best zero and range stability available. It does not run into trouble when non-hydrocarbon materials are present in samples. Since it does not burn in order to analyze, deposits do not form in the detecting element and flash-back protection is unnecessary. Maintenance problems are kept to a minimum.

When you specify continuous analyzers for your process streams, P-E alone has a complete line of instruments to choose from. Or let us develop a complete analytical control system for you. Nowhere else can you get the combination of chemical engineering and instrument know-how that you'll find at P-E.

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P-E TRI-NON Analyzers are available in a wide range of models and prices to meet all types of continuous analytical problems. They are rugged and dependable, expressly designed for use in the varied environments of a processing plant or refinery. For quick and easy maintenance, instrument components can be tested right on stream — without disconnecting.

What's Happening

MARCH 1956 FEATURE NEWS

- **LMFR Fascinates ChE's** 114
  Continuous breeder reactor offers cheap power from U-233 dissolved in molten bismuth.

- **New Data Fill Vacuum** 116
  Here are the first published data on heat transfer in parallel flow outside cylinders.

- **New Head Design Distributes Flow Evenly** 118
  Other benefits: Low holdup, less pressure drop through tubular heat exchangers.

- **Balls Keep Solids Moving** 120
  They also speed up rate of heat transfer in rotary kilns used for drying, calcining.

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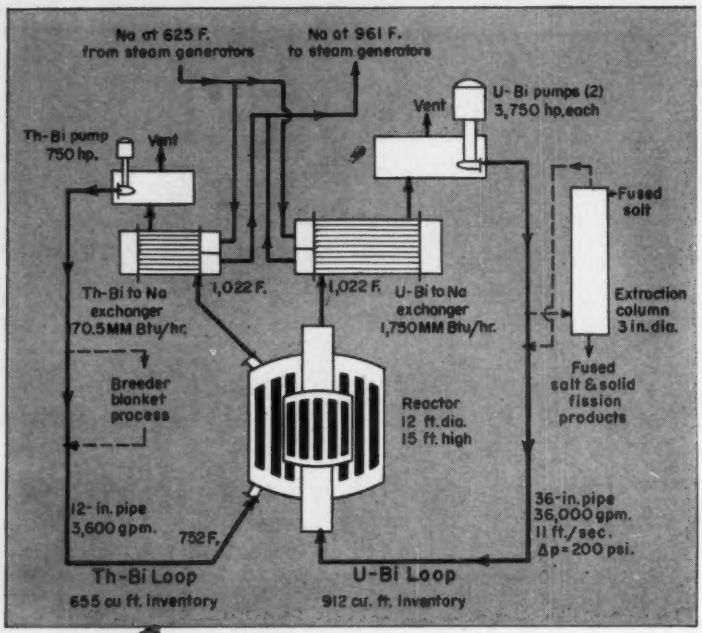
FROM THE NUCLEAR CONGRESS . . .

5 Ideas of Most Significance to ChE's

THIS past year furnished two outstanding examples of how engineers and scientists in the nuclear field can exchange significant technical information without jeopardizing national security.

While the Geneva Atoms-for-Peace Conference in August got more space in the lay press, the Nuclear Engineering and Science Congress in Cleveland in December provided a technically solid bill of fare for its 2,834 registrants.

Of the 251 Congress papers sponsored by 26 technical societies CE's editors have selected five as having the greatest interest and usefulness to the nonnuclear chemical engineer. These we have condensed and interpreted for you here.



LMFR Fascinates ChE's

Continuous breeder reactor offers cheap power from U-233 dissolved in molten Bi.

The flow diagram above represents "one of the most promising schemes proposed to date" for generating power from the atom—the liquid-metal-fuel reactor, or LMFR.

This is the opinion of a special study team composed of ten utility and power-apparatus engineers working during the past two years at Brookhaven National Laboratory, Upton, N. Y. Two members of the team, Donald J. Sengstaken and Edwin Durham,* reported on the team's engineering-economic study to the Nuclear Engineering Congress.

▶ **Continuous Process** — The LMFR has a special attraction for the chemical engineer, for it's a truly continuous, fluid-flow process.

The fuel is a dilute solution (670 ppm.) of uranium-233 in molten bismuth, rising in temperature as it passes through a graphite-moderated core and giving up this energy to liquid sodium as it passes through a tubular exchanger. The sodium,

*Sengstaken is with Long Island Lighting Co., Durham with Babcock and Wilcox. Other firms represented on the team are Westcott and Mapes, Inc., United Illuminating Co., Housatonic Public Service Co., Western Massachusetts Electric Co., along with City College of New York.

Non-Nuclear Chemical Engineers

Estimated Capital Costs for 200-mw. LMFR Station

Reactor-boiler plant	
Reactor vessel	$1,000,000
Heat exchangers, boilers	2,450,000
Piping, valves, etc	2,300,000
Pumps	1,000,000
Auxiliary loop systems	900,000
Controls, instruments	350,000
Fuel, blanket, waste processing	9,000,000
Structures, improvements	2,500,000
Reactor-boiler total	$19,500,000
Turbine-generator plant	10,900,000
Substation, electrical accessories	2,150,000
Other plant equipment	300,000
Land and land rights	350,000
Engineering and indirects	7,400,000
Interest during construction	2,200,000
Contingencies	950,000
Total fixed capital	$43,750,000
Bi, Na, NaK inventories	3,000,000
Uranium inventory	4,650,000
Thorium inventory	1,500,000

in turn, flows through its own loop, giving up the energy it got from the U-Bi solution by turning water into 1,250-psig., 900 F. steam. The steam, finally, produces electric power via a conventional turbine.

A thorium breeder-blanket loop, containing a slurry of Th_3Bi_5 in Bi, surrounds the central core in the reactor and provides 10% of the total energy to the generation plant.

A small sidestream bled from the fuel loop is continuously reprocessed to remove solid fission products. Similarly, U-233 bred in the blanket loop is recovered continuously.

▶ **Is It Feasible?**—Pioneered by Brookhaven Laboratory, the LMFR has many decided advantages. BNL engineers early realized, on the other hand, that a lot of top-notch development work would be needed before the concept could be turned into reality.

The team of guest engineers looked into the areas requiring further development and concluded that early solutions of the engineering problems were possible. Indeed, research results recently obtained by BNL and by industry indicate that some of the problems may already be solved.

Among the advantages seen for LMFR are:

- Relatively simple construction.
- Simple fuel handling by pumping.
- No need to shut down for "reloading" of fuel.
- Low pressures throughout the reactor unit.
- Relatively inexpensive system for continuous fuel, blanket and waste processing integrated into the reactor system, so that operation of a power station is independent of other industry except for supply of basic fuel and chemicals.

▶ **Is It Economical?** — Sengstaken and Durham report an estimated energy cost for a 200-mw. station of 7.5 mills/kwh. This is based on a plant-utilization factor of 80%, 30-yr. life for the turbine plant and 15-yr. life for the reactor-boiler plant.

Total estimated plant cost is about $44 million (*see table*). Inventories of liquid metals and fuels tie up $9 million more.

Biggest question mark in the estimate is the $9-million figure for the reprocessing systems. Inasmuch as exact processing schemes haven't yet been developed, this is at best only a rough approximation. The team considers the rest of the capital cost estimate reasonably reliable. And since fixed charges on capital comprise about two-thirds of the total energy cost, the 7.5-mill figure (which also includes a liberal $2.5 million per yr. to operate the reprocessing plant) seems to be fairly realistic.

This means that the LMFR power plant would be economically competitive with many fossil-fuel-fired power stations.

▶ **Auxiliary Systems**—In addition to the fuel, breeder-blanket, sodium and steam loops, LMFR requires several auxiliary systems.

A NaK system maintains the temperatures of the U-Bi and Na systems within definite limits to prevent freezing of the metals and also provides for emergency cooling of the fuel. A helium system is required for pressurizing the U-Bi, Na and NaK circuits and to preheat the reactor core prior to loading.

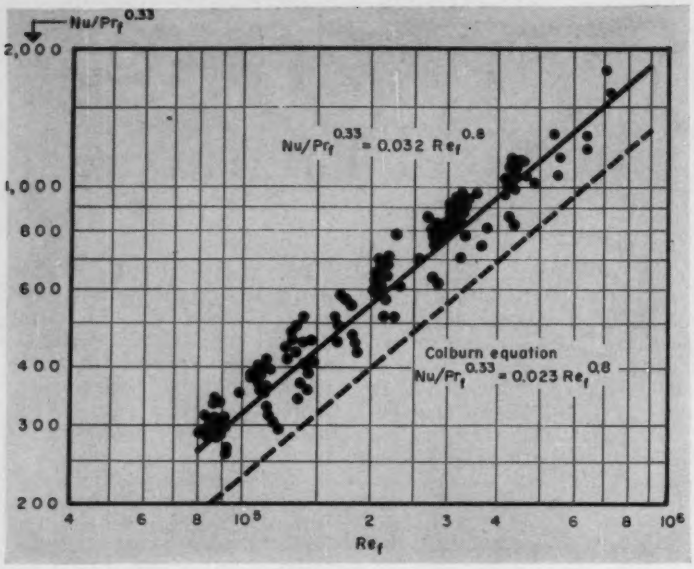
Finally, a cooling system uses a closed air-circulating loop to remove heat from the concrete reactor room walls. Object is to prevent dehydration of the concrete, which would reduce its shielding effect.

▶ **Equipment Highlights**—In addition to the data shown on the flowsheet, the following information on equipment design is of special interest:

Inner core of the reactor consists of a solid graphite cylinder, 5 ft. dia. by 5 ft. high. It's drilled with 2-in.-dia. holes on 2.7-in. triangular centers to get the desired 1:1 volume ratio. Outer section of the reactor is composed of 3.2-in.-dia. graphite rods on 4.3-in. centers. Core and blanket sections are separated by a graphite vessel.

Principal material of construction for the liquid-metal systems is 2¼-Cr, 1-Mo steel. This alloy is suitable provided oxygen content of Na and NaK at 1,100 F. is below 0.02%.

To minimize costly inventories, fuel and breeder-blanket loops have been designed with minimum holdup. Liquid-metal pumps will probably be of the canned-motor type; however, consideration is also being given to electromagnetic pumps.



New Data Fill Vacuum

Here are first published data on heat transfer in parallel flow outside tube bundles.

If you wanted some experimental data or a general correlation for the case of heat transfer to a fluid in turbulent flow parallel to bundles of tubes or rods, you might expect to find some help in the literature.

This was the expectation of several engineers at the Walter Kidde Nuclear Laboratories, Garden City, N. Y., as they began to study a problem in nuclear reactor design. Of the large variety of designs that are under serious consideration, many involve parallel heat transfer from lattices of cylindrical rods at high heat fluxes and large Reynolds numbers.

In particular, some of the proposed designs contemplate the use of pressurized water at high temperatures as the heat-transfer medium for a power-producing reactor. Technically and economically, it's important to know the heat-transfer coefficients for reactor cooling with considerable accuracy.

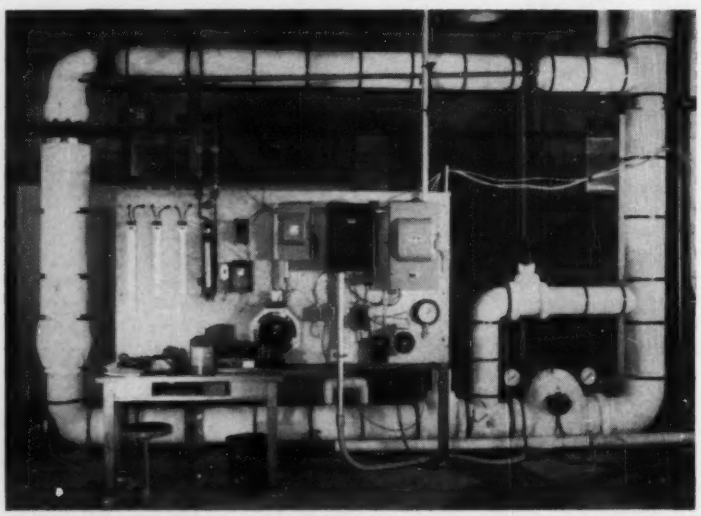
▶ **Little Help in Print** — The Kidde engineers* reported to the Nuclear Congress that they found almost no help at all in the engineering literature. There are no published data—only some proposed theoretical correlations. This lack of published information on parallel flow heat transfer reflects the scarcity of its occurrence in chemical process equipment. Parallel flow would be used only for special designs—and now, for nuclear reactors.

One proposed correlation has been recommended by Eckert ("Introduction to the Transfer of Heat and Mass"). He suggests using the Colburn equation for turbulent flow inside tubes, but with an equivalent diameter equal to four times the cross-sectional flow area divided by the wetted perimeter.

However, Eckert cites no experimental data to back up his recommendation. Because of this, the Kidde engineers undertook their own experimental investigation of parallel flow heat transfer to water flowing through a lattice of cylindrical rods. Experimental results are shown in the graph.

▶ **Disagrees With Theory** — In the Kidde test loop heat transfer was measured for water flowing parallel to 37 ⅜-in. rods, 4 ft. long, in a lattice of 0.914-in. triangular spacing within a 6¼-in. I.D. cylinder. Velocity varied from 5 to 20 ft./sec.; temperature from 150 to 325 F.; and heat flux from 50,000 to 200,000 Btu./(hr.)(sq. ft.). Reynolds numbers ranged from 70,000 to 700,000.

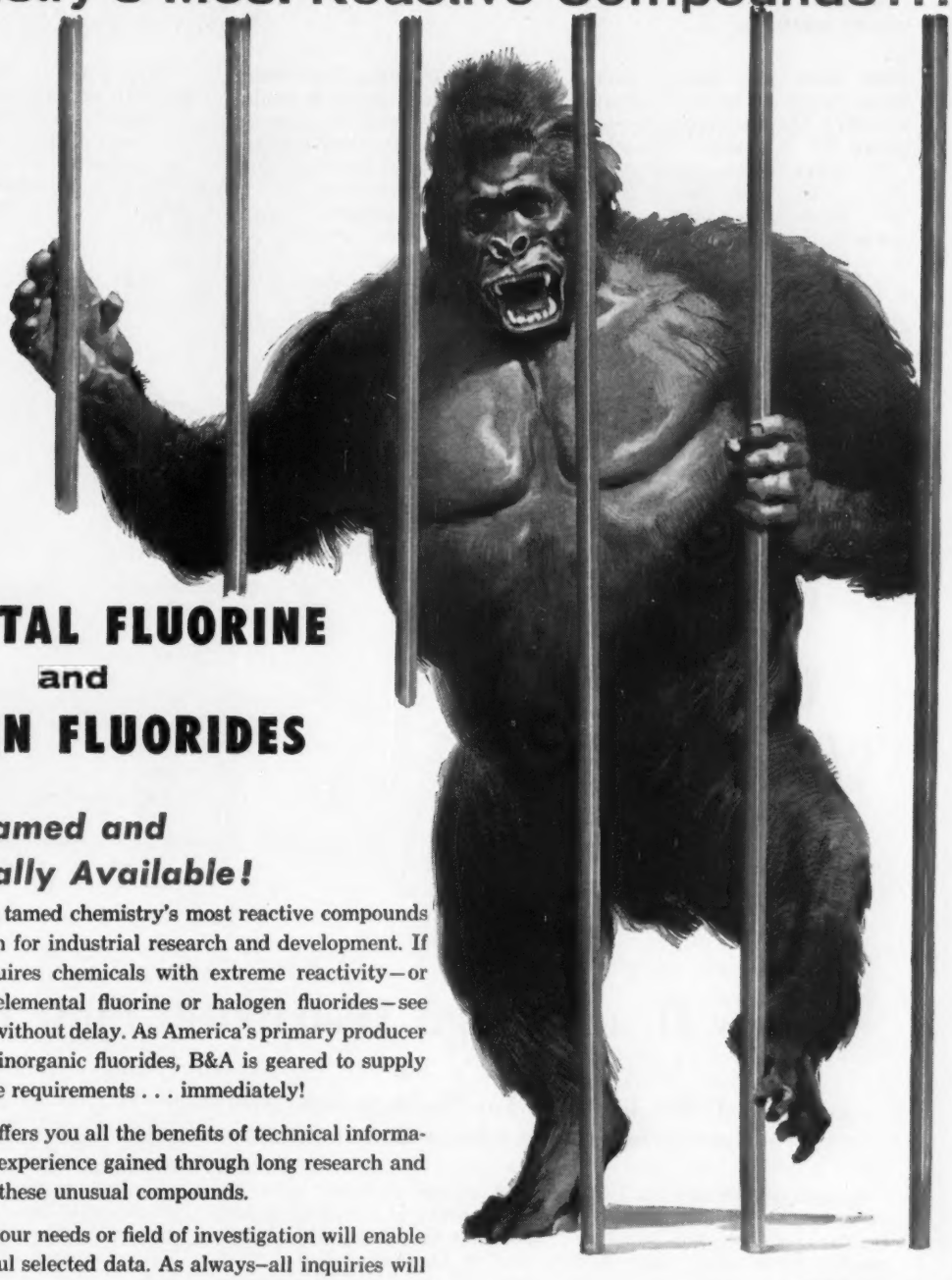
Heat-transfer coefficients calculated from the experimental



EXPERIMENTAL heat-transfer loop used water flows up to 1,100 gpm.

*Philip Miller, James J. Byrnes and David M. Benforado.

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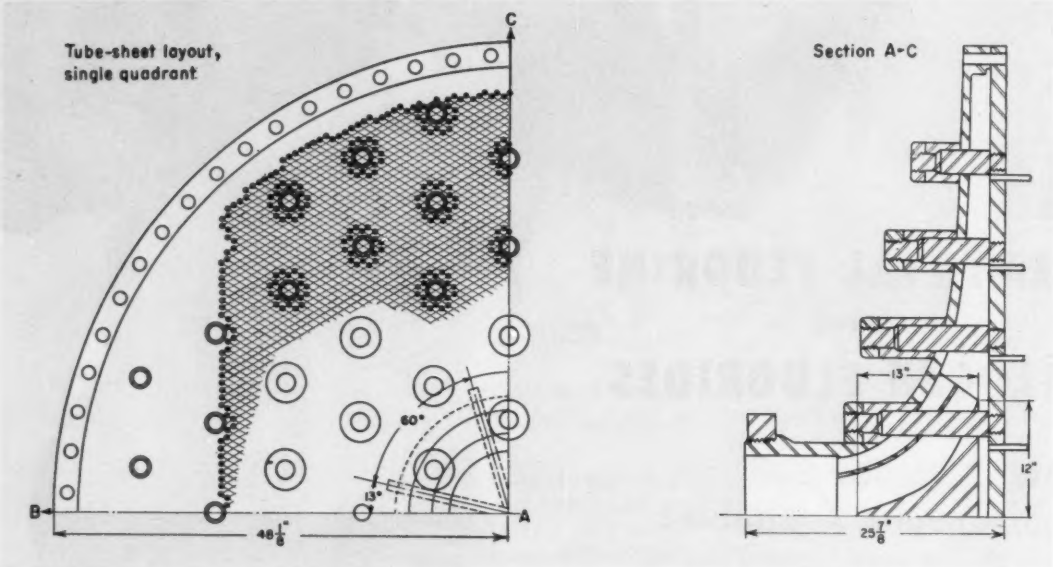
GC Allied Chemical

data were 40% higher than those predicted by the Colburn equation for flow inside pipes, using the equivalent diameter.

Pressure drops were 65% higher than those predicted by the Fanning equation, also using the equivalent diameter.

▶**Note of Warning**—Although the Kidde correlation is analogous to the widely accepted Colburn equation, the Kidde engineers point out that their correlation may not prove correct for lattices of different dimensions than the one studied.

They plan to collect more data for varying conditions. In the meantime—although a general relationship for this case has not been conclusively established—an important gap in the field of heat transfer has now been filled.



New Head Design Distributes Flow Evenly

Other benefits: Low holdup, less pressure drop through tubular heat exchangers.

A special design of heat-exchanger head, developed by Du Pont engineers for a nuclear reactor installation, may find application in non-nuclear fields where uniform flow distribution to the tubes is required.

As reported to the Nuclear Congress by M. T. Cichelli and D. F. Boucher of Du Pont's Engineering Research Laboratory, Wilmington, primary objective of the new head design for the nuclear installation was to reduce the holdup of costly process fluid. Secondary objectives were uniform flow distribution and low pressure drop.

In commercial use, however, the benefits of low holdup and pressure drop may take a back seat to the advantages gained by uniform flow distribution. For example, performance of a continuous-flow, tubular reactor system may be improved by insuring even distribution of reactants to the tubes. The new head design may be a good way to achieve this objective.

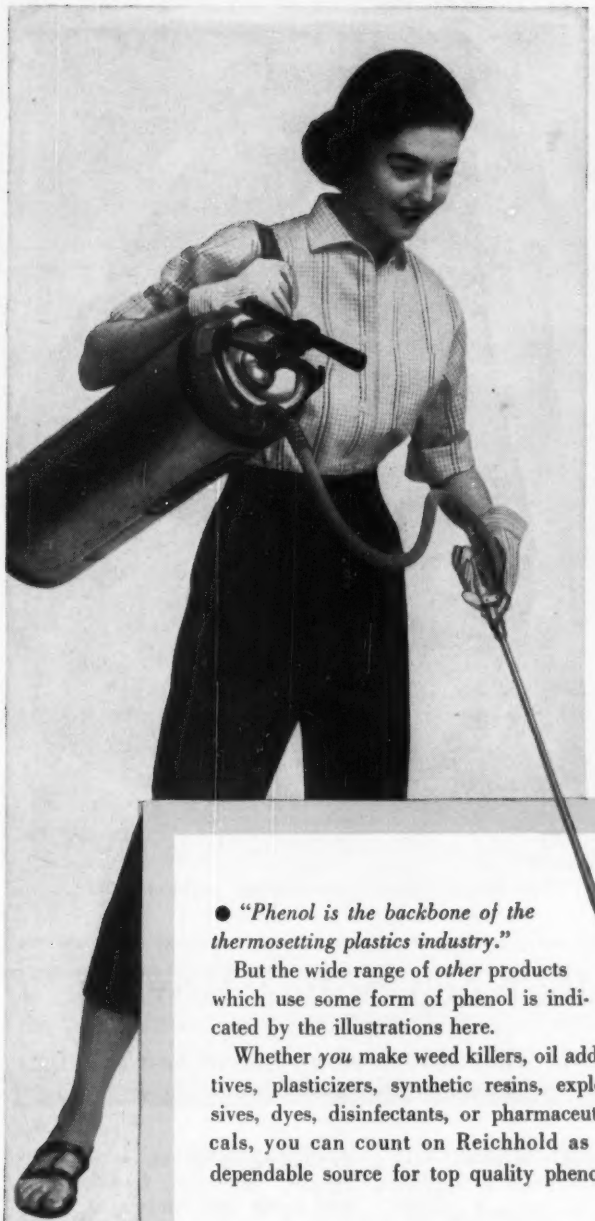
▶**Challenging Problem** — Cichelli and Boucher faced an unusual problem when they began their work.

Need for minimizing the inventory of process fluid in the nuclear system dictated that the exchanger heads have the lowest practical volume. A conventional head with a distance of only 9 in. from cover to tube sheet would have a holdup volume of more than 25 cu. ft. Their goal was a holdup of only 9 cu. ft.

Minimizing the volume of the entire flow system meant also that the line sizes must be small. The resulting high liquid velocities required that special attention be given to pressure drop in the heads and to flow distribution among the tubes. High velocities also demanded special consideration of the possibility of failure due to vibration actuated by fluid flow.

Unequal flow among tubes in

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a heat exchanger is caused by differences in the pressure drop across some tubes as compared to that across others. This unequal flow, states Cichelli, reduces the effectiveness of an exchanger and can appreciably increase its cost per unit of productivity.

The Du Pont investigators studied two factors which cause unequal pressure drop across heat-exchanger tubes—friction loss in the heads and uncompensated pressure variations due to momentum changes in the heads. They decided, after digging into fluid-flow fundamentals, that the friction loss was relatively unimportant in the designs considered, that momentum transfer was controlling.

▶ **Effective Solution** — Final head design is shown in the drawing on p. 118. Holdup volume is 8.9 cu. ft. Calculated pressure loss for inlet and outlet heads combined is equivalent to 0.4 inlet-pipe velocity heads, and the calculated maximum unbalance in pressure drop across the tubes is 1%.

Main features of this design are:

- A streamlined deflector to turn the main flow and reduce holdup volume.
- A splitter vane and radial vanes in the region of turning flow to prevent losses due to separation.
- Approximately constant area of channel normal to flow at any radius beyond the deflector piece.

Beyond the edge of the deflector piece the flow is essentially parallel to the tube sheet. In this region the head cover is a surface of revolution generated by rotating a rectangular hyperbola about the pipe axis. Mechanical strength is promoted by the use of staybolts, which also serve to position the head cover with respect to the tube sheet.

Cichelli and Boucher can well be proud of their accomplishment, for the full-scale exchanger installed in the plant has yielded the expected savings in reduced inventory of process fluid and reduced power for pumping, while operating free of trouble.



BENCH-SCALE unit demonstrated to Brookhaven engineers that . . .

Balls Keep Solids Moving

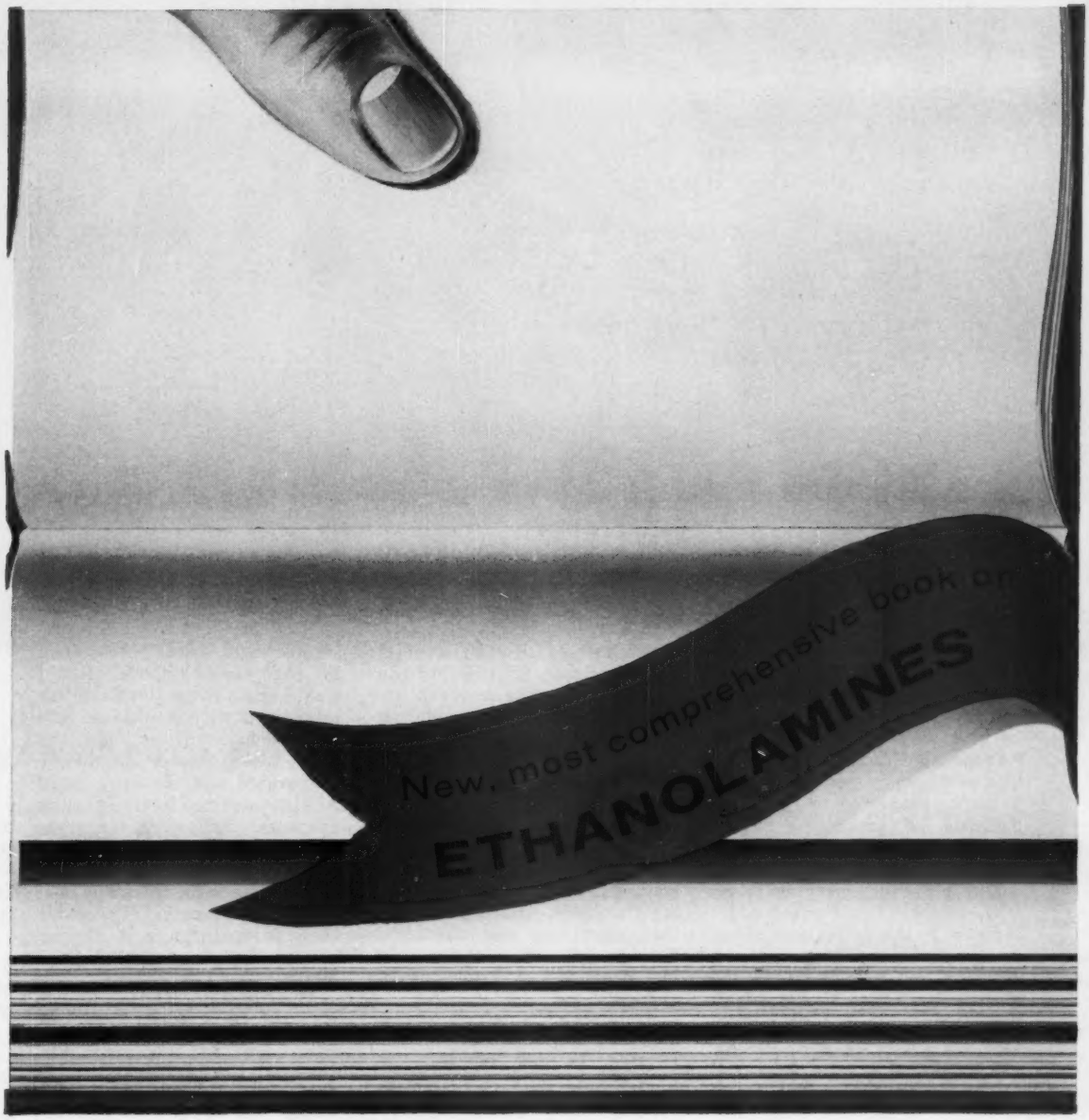
They also speed up rate of heat transfer in rotary kilns used for drying, calcining.

A new wrinkle in rotary kiln design was disclosed at the Nuclear Congress by L. P. Hatch and W. H. Regan, Jr., of Brookhaven National Laboratory, Upton, N. Y.

Developed as part of an overall study of the disposal of fission products from nuclear power plants, the new kiln might be described as a combination ball mill and rotary kiln. The balls, rolling gently within the slowly revolving kiln, serve two functions—they greatly improve the rate of heat transfer and they keep the solids from agglomerating, producing a product which is roughly spherical, free-flowing and fairly uniform in size. The balls don't do any grinding in the usual sense.

Brookhaven engineers are enthusiastic about the prospects of developing the ball-kiln idea on a large scale. Operation of a 5-in.-dia. by 8-in-long bench-scale unit (*see photo*) has convinced them that the idea is feasible. Outside engineering studies leading to working designs are under way.

Next step will be a pilot plant, with a kiln of, say, 12 to 24 in. dia. and possibly 5 ft. long.



. . . 54 pages on —

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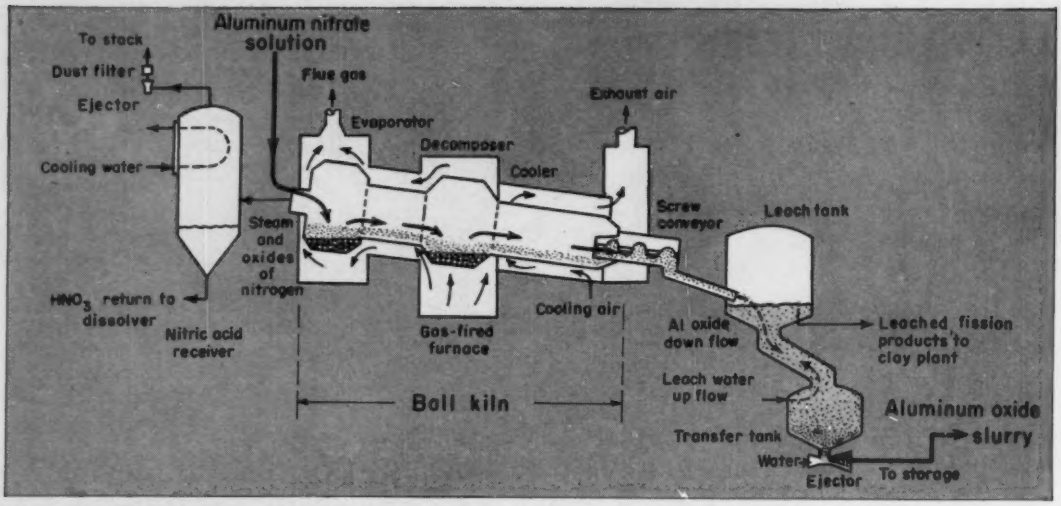
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EVAPORATION, drying and calcining in ball kiln is key step in disposal of nuclear wastes.

In spite of the unusual design problems because of the hazards involved, equipment and development costs, it is hoped, may be kept below $500,000.

▶**Disposal Process**—The ball-kiln research is part of Brookhaven's program to develop methods of processing high-level nuclear wastes for ultimate disposal.

One proposal emerging from BNL which has attracted wide interest is the permanent storage of fission products via adsorption and fixation on montmorillonite clay. Under ideal conditions just a few pounds of clay could hold the daily output of hazardous waste products from a 500,000-kw. power reactor.

Based on today's concepts of reactor design and fuel processing methods, however, conditions for adsorption of fission products on the clay are far from ideal. Waste solutions would contain relatively large amounts of other ions which interfere heavily with the ion-exchange processes. Examples are the hydrogen ion (in wastes from processing solid uranium fuels) and aluminum and zirconium ions (from processing solid fuels made of these metals alloyed with uranium and/or thorium).

Where the ball kiln fits into the picture is in the pretreatment of raw wastes to convert aluminum nitrate and zirconium and aluminum fluorides to the stable oxides. The nitrogen oxides and HF which are driven off can be absorbed in water to produce nitric and hydrofluoric acids for reuse in the fuel reprocessing plant.

▶**Engineering Problems**—Although calcining aluminum nitrate containing fission products may well involve new engineering standards. Hatch points out that aluminum and zirconium fluorides offer the real problems in process and equipment development.

Aluminum nitrate decomposes to the oxide merely by heating at temperatures no higher than 350 C. Stainless steel appears to be entirely suitable.

The fluorides, however, don't decompose as easily. They must be heated to above 600 C. in the presence of steam as a hydrolyzing agent. Stainless steel won't stand up under HF at such temperatures. Hatch isn't even sure that Monel or Inconel will do.

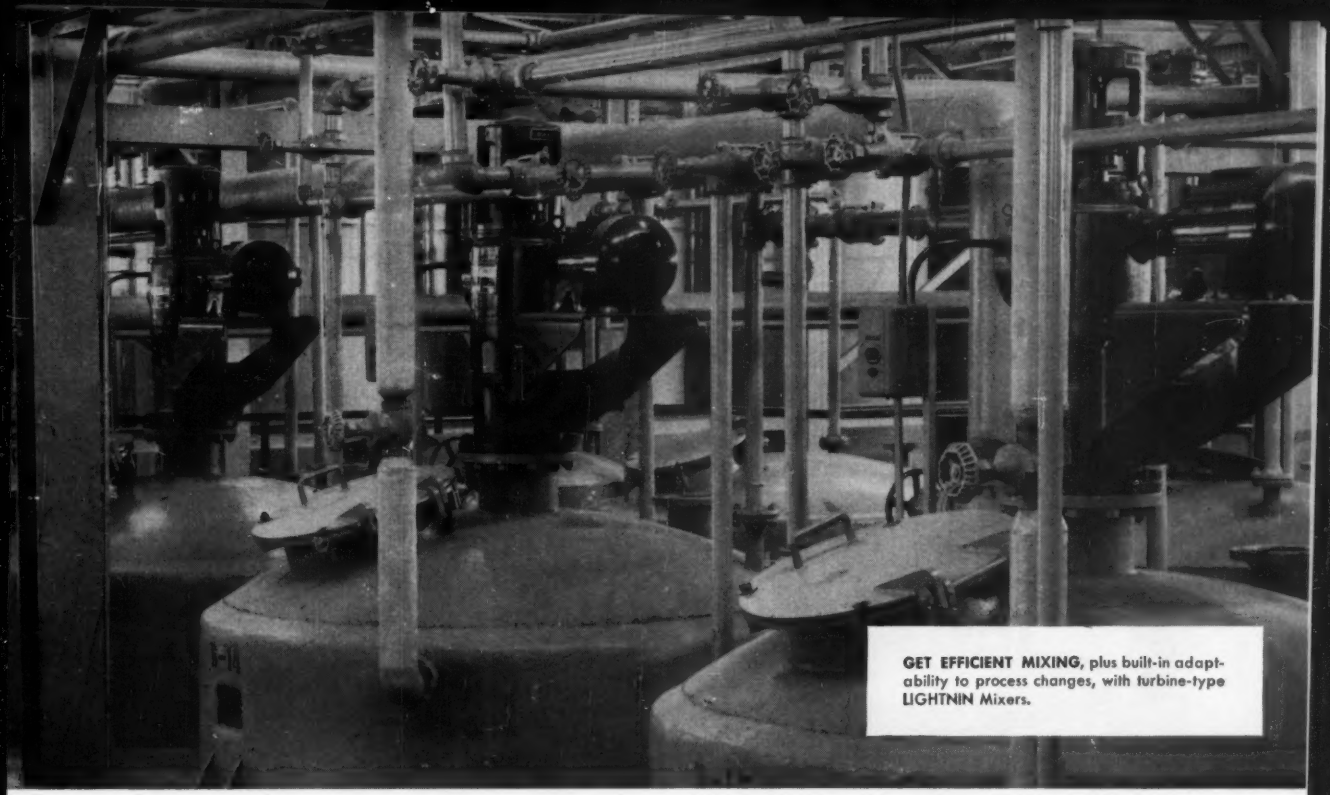
In order to localize the toughest problems, Hatch visualizes a two-stage conversion process using two separate kilns. The first kiln, of stainless steel, would drive off the nitrate under relatively mild conditions. The second kiln would then hydrolyze the fluorides under more severe conditions.

▶**How Kiln Works**—As shown in the sketch above, liquid waste containing aluminum nitrate in solution would feed into the first ball-mill section of the kiln, where water would be evaporated and the dehydrated $AlNO_3$ converted to free-flowing granules. Following the slope of the kiln, the nitrate salt then passes to the second ball-mill section. Here the nitrate is converted to the oxide. The oxide then flows through a cooling section and is collected in a water-sealed tank.

The calcining section is surrounded by a direct-fired furnace. Hot flue gas from this furnace passes through the evaporator furnace before discharge to a stack. Alternatively, electric heating could be used.

Water vapor and nitrogen oxides leave at the upper (feed) end and are condensed. Any dust escaping the kiln in the gases is captured in the condensing vapors or by subsequent separators. The condenser operates under a slight negative pressure.

Hatch is thinking in terms of a ball kiln about 4 ft. dia. by 20 ft. long for a full-scale unit. A kiln this size would probably handle the complete load of a single fuel-reprocessing plant. The reprocessing plant itself might be serving several large (500 mw. or better) power-generating reactors.



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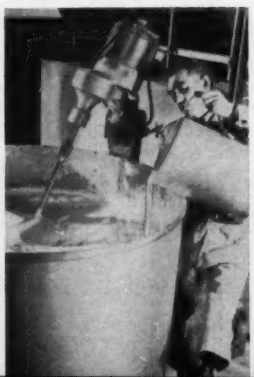
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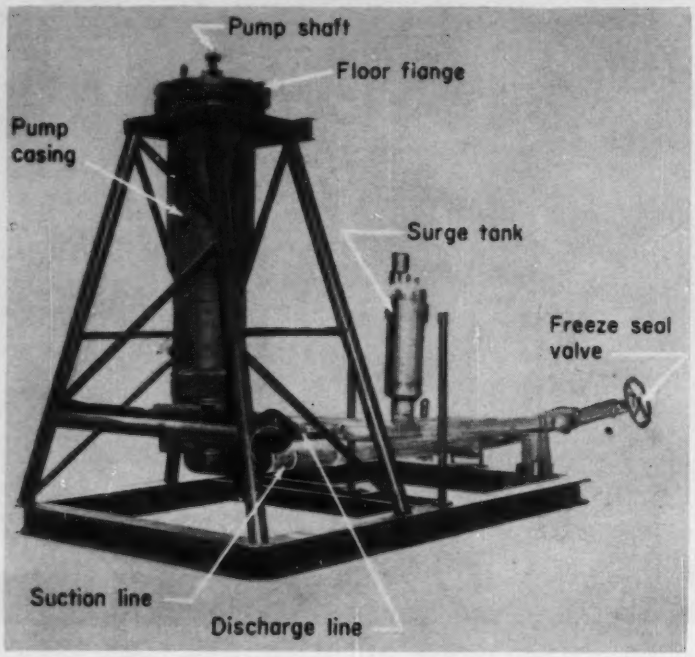
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Frozen Slugs Seal Shafts

Easily adapted to standard equipment, new seal simplifies handling of liquid metals.

A novel seal for rotating shafts of pumps and valves handling high-temperature liquid metals was described to the Nuclear Congress by R. Cygan and A. M. Stelle of North American Aviation, Canoga Park, Calif.

Operating principle of the new seal is the formation of a barrier between the liquid-metal system and the outside by freezing a slug of the metal in a narrow passage. The frozen metal is held in the narrow passage, which is usually an annulus, by friction and adhesion.

▶ **Opens New Fields** — In the past, engineers in non-nuclear fields have shied away from high-temperature liquid-metal systems because of unfamiliarity with the distinct advantages of such systems and because of high equipment costs. More recently, declassification of a great deal of engineering know-how on liquid metals has virtually wiped out the first of these obstacles.

The new seal design will help overcome the second obstacle. Outstanding feature is the relative ease with which it can be adapted to commercial equipment. Valves can be converted merely by adding a new bonnet incorporating cooling passages along the stem. Centrifugal pumps can also be modified to use freeze seals, though the modifications are more extensive than with valves.

Based on their experience in operating and testing freeze seals, the NAA engineers rate them as "reliable and efficient." They predict long service life if the liquid metal being sealed is free from abrasives and the coolant doesn't foul the cooling passages too much.

They also foresee use of the freeze-seal principle for slip expansion joints in piping, remotely operated freeze-off valves, instrument lead-throughs and a variety of other applications. Future simplification in design of the freeze seal, they believe, will broaden its field of usefulness and increase its reliability.

▶ **How It Works**—In a rotating freeze seal, the frozen metal is continuously sheared at the shaft surface, and a thin, high-viscosity liquid film is maintained at the shear interface. Although the exact action is not known, Cygan and Steele theorize that friction energy supplies the heat necessary to maintain the liquid film, and the high thermal conductivity of the frozen metal permits heat to be removed so fast that the film doesn't become thick enough to allow leakage.

Heat is removed continuously from the frozen area by a liquid or gas coolant; liquid cooling gives the more compact design. Cooling requirements are not excessive. Close temperature control of the seal does not appear necessary as long as the temperature of the frozen metal is kept well below its freezing point.

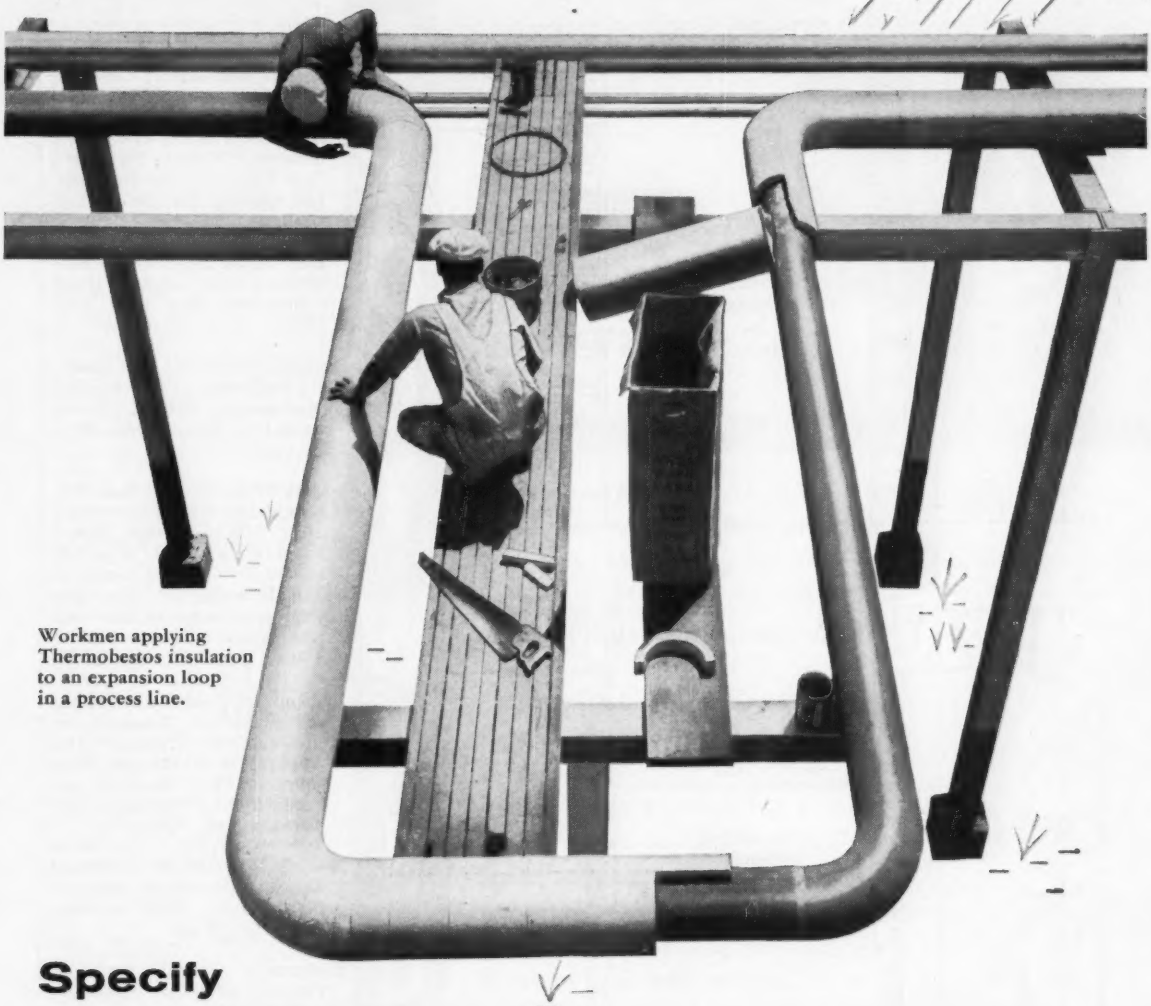
▶ **Practical Considerations** — Vertical shaft seals present no problem in achieving a solid plug around the entire annulus. With horizontal shafts, some difficulty may be met. Pumps and valves, therefore, should be mounted vertically for best results.

Standard shaft finishes appear to be satisfactory; hard surfacing is unnecessary. Wobble and vibration of a pump shaft must be kept below 0.001 in. total indicator reading. Pump shaft deflection due to hydraulic or gravity load should be kept under 0.004 in.

As pointed out also in several other Congress papers, oxygen content of a liquid sodium system must be kept very low in order to avoid the precipitation of abrasive oxides in the cooler regions. These oxides would ruin a freeze seal. The gas side of the seal, therefore, must be covered with an inert atmosphere, particularly if the metal is easily oxidized.

▶ **Practical Experience** — North American has tested several freeze-seal designs on centrif-

When you're fighting the weather as well as heat loss



Workmen applying Thermobestos insulation to an expansion loop in a process line.

Specify

J-M THERMOBESTOS® the heat insulation designed for outdoor process industries

Here's proof that rugged physical strength and high insulating efficiency can be combined in one material. J-M Thermobestos is strong and rigid, yet light enough for easy handling and fast application. It is not damaged by prolonged wetting. Its hard composition resists crushing and will withstand unusual service abuse. The low conductivity compares favorably with other accepted industrial insulations.

This unique combination of properties means excellent temperature control and minimum maintenance cost for oil refineries, chemical processing plants and other plants with outdoor vessels and hot piping.

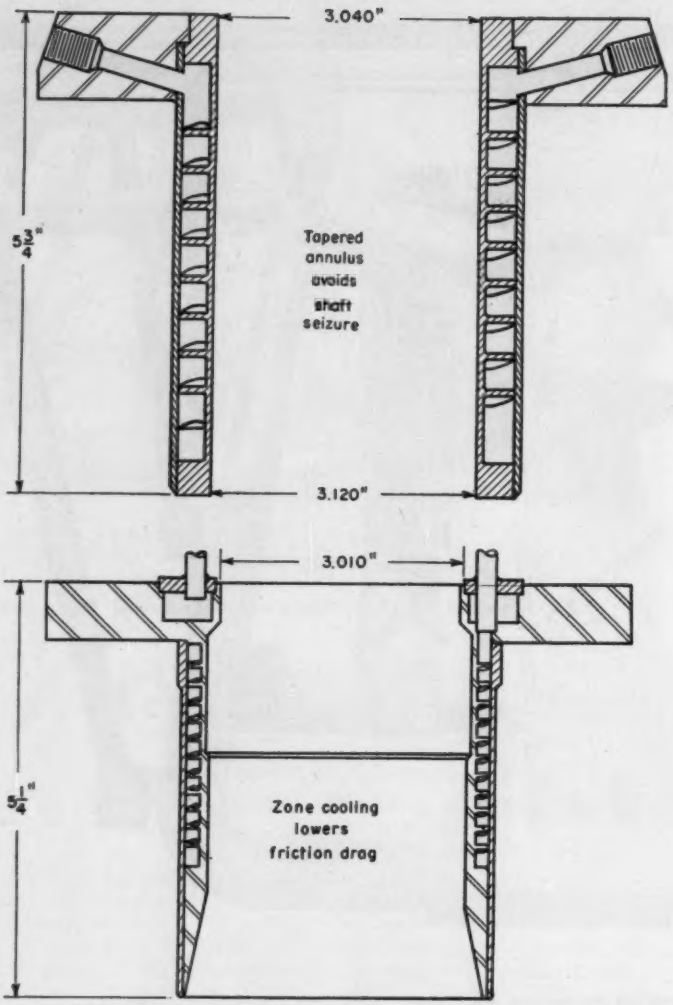
Made from calcium hydrosilicate, Thermobestos is molded to size for proper fit. Its high strength makes it particularly adaptable for time-saving shop prefabrication of fittings and bends. Furnished in large sections, Thermobestos is easy to apply. It reduces the number of joints. In pipe insulation form, it comes in a complete selection of sizes up to 24″ x 3″ half-sections. Also available in 6″ x 36″ and 12″ x 36″ blocks in a full range of thicknesses. For further information write to Johns-Manville, Box 60, New York 16, N.Y. In Canada, Port Credit, Ontario.

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MATERIALS · ENGINEERING · APPLICATION

Freezer Seals for 3-In.-Dia. Pump Shaft



ugal pumps. In the first seal the annulus containing the frozen metal had parallel walls with a clearance of 0.032 in. This design was discarded because of erratic power surges and shaft seizure.

The next design (*upper sketch*) had a tapered annulus—0.02 in. clearance on the cool side and 0.06 in. on the hot side. This design gave no trouble with power surges and seizures.

A later design (*lower sketch*) uses two independent cooling surfaces. The upper annulus has parallel walls with a clearance of only 0.005 in. Clearance in the lower annulus, also parallel, is 0.158 in. The lower cooling circuit provides precooling of the liquid metal in the wide annulus so that any precipitated oxides can be segregated before getting into the narrow upper annulus. The short axial length of frozen metal and the thinness of the liquid film in the upper annulus minimize running and starting torques.

North American is now testing further modifications of seal design. Among the goals are the allowance of greater misalignment and wobble in the shaft and reduction of the breakaway torque.

Convention Calendar

American Institute of Chemical Engineers, national meeting, including symposia on "Current Status of the Completely Automatic Process Unit" and "Air Pollution," Statler Hotel, Los Angeles, Feb. 26-29.

American Management Assn., 2nd annual electronics conference and exhibit, Hotel Commodore, New York, Feb. 27-29.

Chemical Institute of Canada, 6th conference of the chemical engineering division, Guildwood Inn, Sarnia, Ont., Mar. 5-7.

Society of the Plastics Industry, 14th annual Canadian conference, Sheraton-Brock Hotel, Niagara Falls, Ont., Mar. 8-9.

National Assn. of Corrosion Engineers, corrosion show and 12th annual conference, Hotel Statler, New York, Mar. 12-16.

Institute of Food Technologists and Southwest Research Institute, "Food Physics: The Application of Physical Principles in Food Research and Production," Plaza Hotel, San Antonio, Tex., Mar. 15-16.

Western Petroleum Refiners Assn., 44th annual meeting, Plaza Hotel, San Antonio, Tex., Mar. 19-21.

Eighteenth Annual American Power Conference, highlights nuclear power production, Hotel Sherman, Chicago, Mar. 21-23.

National Assn. of Corrosion Engineers, annual corrosion control short course, University of Oklahoma Extension Study Center, Norman, Okla., Apr. 3-5.

Midwest Research Institute, "Symposium for Management on Applications of Analog Computers," University of Kansas City, Kansas City, Mo., Apr. 10-11.

Metal Powder Assn., 12th annual meeting and 1956 Metal Powder Show, Hotel Cleveland, Cleveland, Apr. 10-12.

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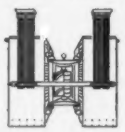
With the acquisition of Richmond Sifters, Sprout-Waldron offers one of the most complete lines of equipment for classifying, grading, and cleaning. This enables your Sprout-Waldron representative to be completely unbiased in his recommendation on the type of equipment best suited to your job. Moreover, he is thoroughly trained to help solve problems for the processing industries. Typical of our representatives is Ray Hubbard, shown here, with ten years of engineering sales experience in the processing industries. For the five years prior to joining Sprout-Waldron, Ray represented the sifting and classification machinery of Wallace & Tiernan.



RAY HUBBARD

Such men can provide professional advice and guidance that can help you lower production costs and raise the quality of your products.

RICHMOND-SPROUT-WALDRON SUPER-SIFTER



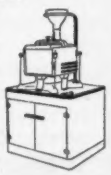
Ceiling suspended, free-swinging. Brings new concepts of accuracy, capacity, durability, cleanliness, and ease of maintenance to the separating of dry, pulverized materials. Available in 2, 4, or 6 sifting sections.

RICHMOND-SPROUT-WALDRON GYRO PEDESTAL SIFTER



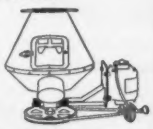
Compact, high-speed. Designed for handling either batches or streams of free-flowing materials containing small percentages of oversizes. Installed in spouting, on columns or on wheels.

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Duplicates results of large, production-type machines. Ultra-modern. Streamlined. Dust-tight. Two types. Provision for time limit sifting. Available with cabinet to keep spare screens.

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Accurately divides a single stream of dry, free-flowing material into 2 to 8 separate and equal streams. Compact. Economical. Dependable.

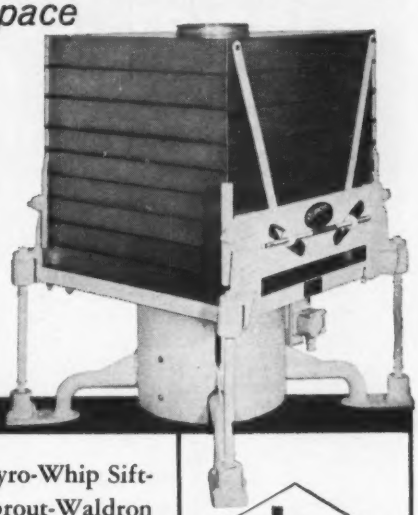
SPROUT★WALDRON

SW

MODERN SIFTING METHOD MAINTAINS UTMOST SANITATION

. . . reduces maintenance and cleaning
. . . saves floor space

RICHMOND-SPROUT-WALDRON Gyro-Whip SIFTERS

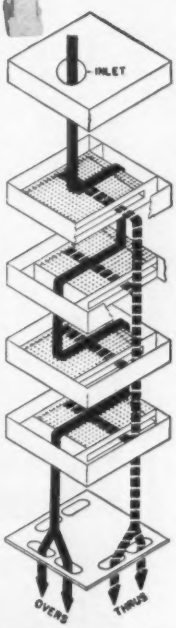


The famous Richmond Gyro-Whip Sifters — now part of the Sprout-Waldron line — are outstanding for their high capacity, low floor-space requirements, sanitary characteristics, and many advanced features.

Simplified design makes possible the most rigid standards of sanitation and reduces maintenance and cleaning time.

The average Gyro-Whip is only 48" high, requires only 3½′ x 3½′ floor space, and operates on only ¾ h.p. Bolting areas range from 47.5 up to 95 sq. ft. Sieves can be of stainless steel, wood, or wood lined with stainless.

The Richmond-Sprout-Waldron line includes models with single stacks of sieves . . . models with sieve stacks suspended from overhead . . . models mounted on pedestals . . . and laboratory models. Installation can be on the "stream." Shipped complete — ready to be connected and operated. Write for full details!



The directional flow for two separations is shown above. Coarse materials, or "overs," drop from sieve to sieve and are discharged through the "overs" channel. The finer particles, or "thrus," sift through to the sieve pans and pass into another channel. Modifications of sieve construction permit from 2 to 6 separations of a single product. Double discharge outlets prevent "backing up" of sifted materials.

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Facilities for fabricating, machining, custom founding, woodworking, laboratory testing

PR/406

Air Pollution Attacked Nationally and Locally

Four air-pollution studies, costing a total of $98,000, will be carried out during fiscal 1956 by the Bureau of Mines in cooperation with the Public Health Service.

One study at Bartlesville, Okla., will explore ways of eliminating or reducing undesirable exhaust gas pollution from vehicles using different types of oils and fuels. Three others, in Pittsburgh, Pa., will study effects of operating incinerators, sulfur-dioxide removal from stack gases and processing plants, and obtaining and analyzing industrial plant stack exhaust samples.

In Washington state, a 24-man advisory committee to help investigate air pollution and to draft suggested legislation has been appointed by the State Legislative Council. Committee members include representatives of General Petroleum Corp., Alcoa and Weyerhaeuser Timber Co.

Reichhold Busy In U. S. and Canada

Hard upon its announcement of a five-year, $25-million program for increasing production facilities comes Reichhold Chemicals' purchase of a Tacoma, Wash., site for a dry adhesive plant and a plant for pentachlorophenol and muriatic acid.

Also in recent weeks, the company started up, then discontinued, merger negotiations with Catalin Corp., New York plastic molding firm.

Reichhold Chemicals (Canada) Ltd., producer of resins chiefly for the paint industry, is well advanced on plans for a big new expansion. Near Kingston, Ont., the company will build a $1-million basic chemicals plant close to the recently completed $20-million Terylene plant of Canadian Industries Ltd., with which there will be some exchange of products. A new phthalic anhydride plant at Ste. Therese, Que., has just gone on stream, as has a new alkyd resin unit at the company's Fort Moody, B. C., plant.



"Snow" Ends Hot-Weather Damage to Concrete

Bechtel Corp. construction engineers had to make "snow" last August to beat 100 F. summer heat which threatened expansion, then contraction and cracking, during curing and cooling of massive (e.g., 8- by 6- by 96-ft. columns) concrete structures. Pulverized ice packed on the aggregate in the forms for columns and beams for 24 hours before a pour minimized this damaging sequence at Tide Water Associated Oil Co.'s Avon (Calif.) refinery during construction of the huge reinforced-concrete framework for a new cooking plant. Usual cooling in place would take elaborate internal pipe coils.

Mg Metal Next For Chemical Milling

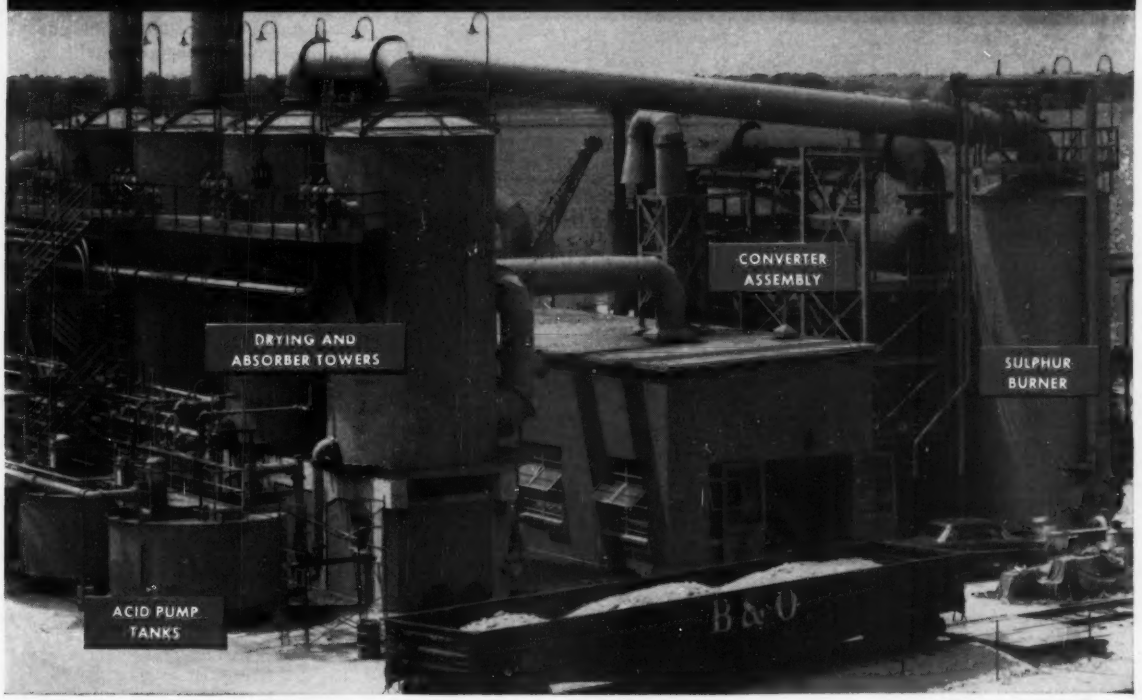
Having already developed a highly efficient etchant for chemical milling of magnesium, Dow Chemical Co. and Turco Products, Inc., have undertaken a joint two-year project aimed at improving control and masking techniques. The basic method, which involves application of closely controlled etching solutions to metals after areas that are not to be disturbed have been masked with a specially developed coating, is already in commercial use for such metals as aluminum. It achieves tolerances as close as plus or minus 0.003 in. in assembly-line operation, is faster and more flexible than conventional milling.

Global Tariff Talks Omit Most Organics

Most of the synthetic organic chemicals facing serious foreign competition have been excluded from current Geneva tariff negotiations between the U. S. and other member nations of the General Agreement on Tariffs and Trade. Some individual producers, however, may feel the impact, notably those who make carbon tetrachloride, methyl alcohol, phenol, saccharin, vanillin and phthalic anhydride—all of which are on the tentative list for possible tariff concessions. However, over-all cuts made during the session, due to wind up early in May, won't be deep, thanks to the limitations on the authority available to the Administration.

CB&I builds

Tanks, Towers and other structures for new chemical plant



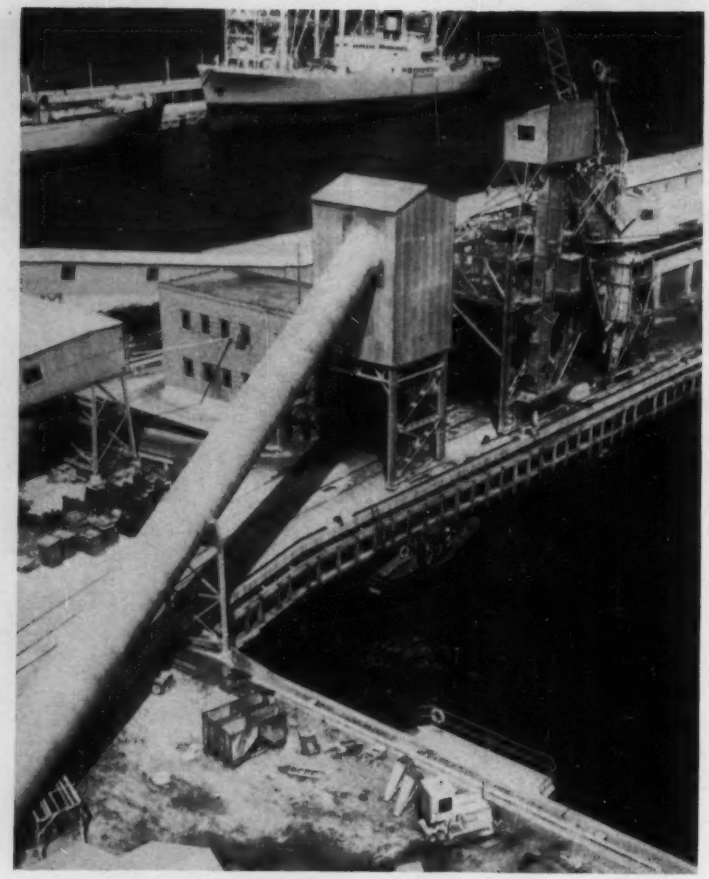
● Shown above are tanks and towers and special steel plate structures fabricated and erected by CB&I for the United States Industrial Chemicals Company at Tuscola, Illinois. If it's true that a "picture is worth a thousand words", this view should speak volumes about the wide variety of tanks and special steel plate structures that we are equipped to build for your processing operations.

When planning new structures, whether it's one tank or outfitting a complete new plant, we would like an opportunity to quote on your needs. Write our nearest office for complete information.

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Tube Supports Conveyor

To support and weather-shield its belt conveyor carrying alumina from storage silos to loading wharf at Port Alfred, Que., engineers at Aluminum Co. of Canada Ltd. pulled a new and better structural approach out of the company's own bag of tricks: They encircled the 148-ft.-long conveyor with a simple cylinder of high-strength aluminum alloy requiring only one mid-span support despite its length and 8-ft.-6-in. diameter.

This straightforward solution, which has proved wholly satisfactory, would have been an economic and engineering impossibility with heavier metals. Conventional method would have been to carry the conveyor on a truss and to enclose it by weatherproof sheathing.

The Alcan structure draws its strength from the cylindrical shell, which is 0.16 in. thick and is reinforced only by internal circumferential aluminum channel stiffeners spaced at 5-ft. intervals. Made of Alcan 65ST sheet, the cylinder was shop-welded into 5- by 30-ft. lengths and then easily and quickly field-bolted into place.

The conveyor—with its unusual housing—fits into the overall ship-loading system at Port Alfred after the alumina has been dumped from hopper cars and raised by airlift 114 ft. through a 10-in. aluminum pipe to fill two large silos. From there the belt conveyor, in combination with airslides and bucket elevator, takes the cargo to the loading tower and into the hold of the ship.

Paragon Plans Rhode Island Refinery

A $38-million, 30,000-bbl.-per-day petroleum refinery will be built by Paragon Oil Co. at Tiverton, R. I., near Fall River, Mass. It will process Gulf Coast crude to make fuel oil, gasoline, high-octane aviation gasoline and jet fuel.

This refinery is the first for Paragon, a leading independent distributor of fuel oil and gasoline in the New York metropolitan area and New England.

A deodorizing plant also is planned, with sulfur output to be sold to Rumford Chemical Co., Rumford, R. I.

Pharmaceuticals Output Boosted Abroad

Mexico's first salicylic acid plant has started producing 30 tons per month in Mexico City. Representing an investment of $136,000—the plant is owned by Salicilatos De Mexico, S.A., in partnership with Heyden Chemical Corp.

In India, a $4 million penicillin plant has been started up near Bombay by a government-owned firm called Hindustan Antibiotics Ltd. The plant has ten 6,250-gal. fermentors. Recent research reports from India suggest that groundnut cake and cane sugar may be the plant's raw materials instead of corn steep water and dextrose.

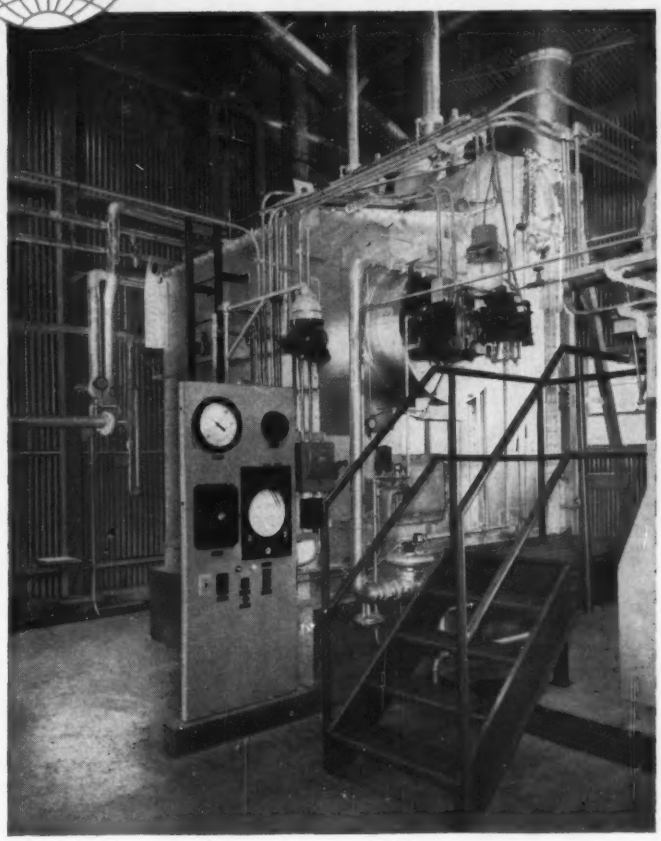
New Bromine Plant Set For Arkansas

A bromine plant will be built in El Dorado, Ark., by Murphy Corp. and Michigan Chemical Corp. To be completed in the fall of 1956, the plant will use brine from the Smackover oil district of southern Arkansas as its raw material feed. The Murphy-Michigan combine may also make other products from the brine stream, including calcium chloride, MgO and salt.

THREE MILLION BTU / HR

for New ATLAS Chemical Plant

FW Dowtherm Vaporizer plays vital role in emulsifier plant of Atlas Powder Company's Chemicals Division





The 3,000,000 btu/hr Dowtherm vaporizer shown above, designed and built by Foster Wheeler, is installed in Atlas Powder Company's new emulsifier plant at Memphis, Tenn. Here, degree-splitting temperature control is a vital factor in maintaining the high quality of Atmul® food emulsifiers used to improve the keeping quality, palatability and appearance of many foods.

Wherever high-temperature, low pressure process heating is required, Dowtherm vaporizers by Foster Wheeler can save time, effort and expense. That's because only FW does the complete job—designs equipment to your exact requirements, manufactures and installs it, puts it into successful operation and provides all necessary servicing. For further details, send for Bulletin ID-54-5. *Foster Wheeler Corporation, 165 Broadway, New York 6, New York.*

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LARGE SLOT AREA offered by 1-in. caps provides high vapor capacity.

Tray Design Saves Space

Low-temperature air-separation equipment must be compact to cut down on cold losses. Bubble-cap fractionation column uses tray spacing of only 4 in.

Atlantic Refining Co.'s recently built 100-ton-per-day ammonia plant at Point Breeze, Pa., uses a bubble-cap fractionating column with unusually low tray spacing for its large diameter.

This column, which produces nitrogen for ammonia by fractionation of liquid air at 75 psi., spaces its 50-odd 4½-ft.-dia. trays only 4 in. apart. It was designed by Hydrocarbon Research Inc., New York, and fabricated of aluminum and stainless steel by Southwestern Engineering Corp., Los Angeles.

This achievement provides American competition for the long-established European fabricators of low-temperature fractionators. Looking to the future, HRI is shooting for even lower tray spacings than 4 in., possibly even 2 in.

▶ **Compactness a Must** — Primary consideration in the design of low-temperature air-separation units is to make heat leak (refrigeration loss) as small as possible. This requires that the equipment operating at low temperature—especially the fractionator—be extremely compact so that it can be enclosed by the minimum size "cold box."

Hydrocarbon Research, long interested in the design and development of tonnage air-separation plants, undertook an experimental program in fractionator tray design for the express purpose of determining the fundamental factors relating to tray capacity and spacing. Successful operation of the Atlantic nitrogen unit is a tribute to the small-scale experimental technique followed in its development.

▶ **Getting the Basic Data** — HRI's development program—involving the study of bubble caps ranging from 1 to 6 in. dia. and perforated trays with 0.04 to 0.25-in. holes, with several liquids of varying physical properties—was completed at a total cost of about $500 for equipment, plus about four man-months of experimentation, correlation and literature study.

This program, from its fundamental approach to its commercial application, was an excellent example of the merits of intelligent "air-water" type of experimentation. It was originally designed to investigate the basic relationships governing tray diameter, tower loads and tray spacing. Its findings were numerous and valuable:

- It provided experimental verification that tray spacing was not fundamentally dependent on superficial tower velocity but, rather, a function of the vapor and liquid flow conditions at the individual caps.
- It yielded correlations of tray spacing, loading and diameter for perforated plates as a function of hole size, percent free area and liquid properties.
- It pointed up the direct analogy between the factors correlating bubble-cap and perforated plate performance, thereby strengthening confidence in basic premises and in design extrapolations and tray variations.

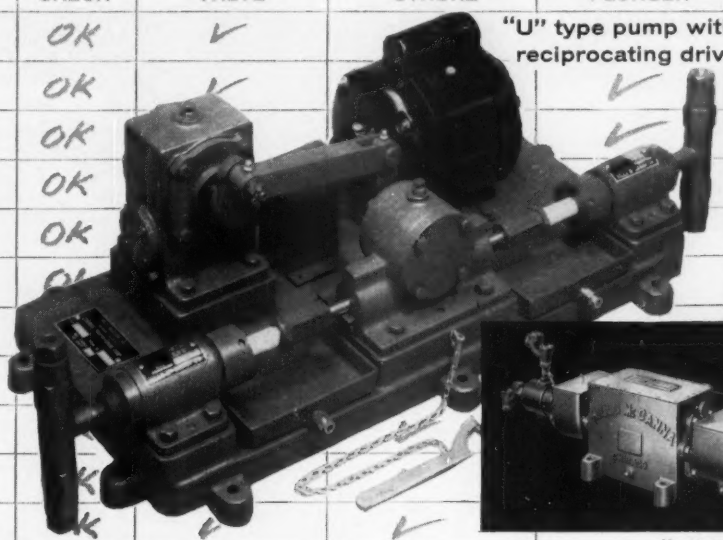
Initial experimentation with single caps showed that such data, properly interpreted, could define conditions on any size tray. These single-cap tests used 2-in. to 6-in.-dia. caps; loadings below those suitable for 12-in. tray spacing were not investigated.

Although extrapolation of the design correlation down to the 4-in. spacing specified for Atlantic's fractionator was fairly well defined, HRI checked this extrapolation by building a small-scale transparent plastic test model of a segment of

Why the FIRST COST is the LAST COST with HILLS-McCANNA METERING PUMPS

PUMP MAINTENANCE REPORT

MONTH	CHECK	VALVE	STROKE	PLUNGER	LUBRICATION
JANUARY	OK	✓			
FEBRUARY	OK	✓		✓	✓
MARCH	OK			✓	✓
APRIL	OK				✓
MAY	OK				✓
JUNE	OK				✓
JULY					
AUGUST					
SEPTEMBER					
OCTOBER	K				
NOVEMBER	K	✓	✓		
DECEMBER	OK	✓	✓	✓	



"U" type pump with mechanical reciprocating drive.

"K" type pump with hydraulic drive.

HILLS-McCANNA dependability pays off in lower maintenance . . . longer life . . . greater accuracy . . . cost-saving versatility

Maintenance reports from the leaders in many different industries prove the low-cost operation of Hills-McCanna metering and proportioning pumps . . . tell why these pumps are specified for installations requiring the finest equipment. Part replacement is remarkably low because there are few points of wear. Routine maintenance is simple and economical thanks to special Hills-McCanna features, such as separate interchangeable check valves and easy, precise stroke adjustment (even while in operation when desired). Working parts are completely enclosed to keep them dirt-free. All U Type pump bodies are interchangeable in the housing for quick convertibility. Straight reciprocal drive eliminates bushing replacement. And, you'll find Hills-McCanna pumps mighty easy to install.

If you must continuously meter or proportion small volume flows with great accuracy, you'll want to consider the "U" type pump—available in 1, 2, 3 and 4 feed units. The "K" type pump —also available in 1, 2, 3 or 4 feed units—will meet your larger flow requirements.

Hills-McCanna can furnish a pump to meet *every* type of installation . . . with a wide choice of corrosion, wear and abrasion-resistant liquid ends . . . in capacities and pressures for every need.

Write for full facts now. You'll be dollars ahead tomorrow by investigating today!

A dependable NEW HEART to put NEW LIFE into your chemical metering system!

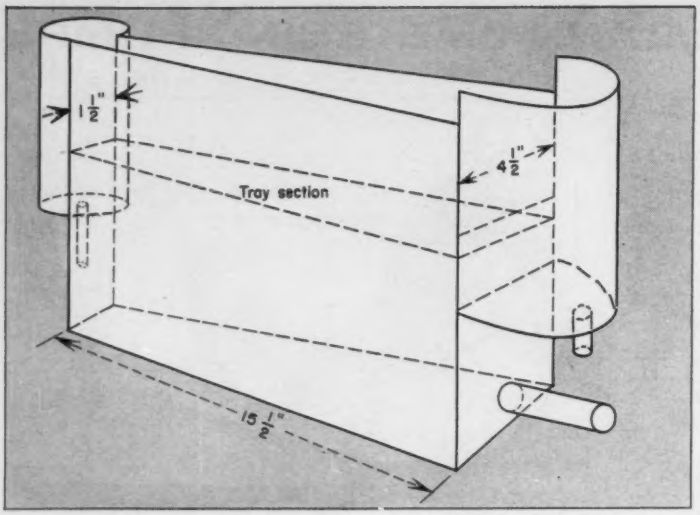
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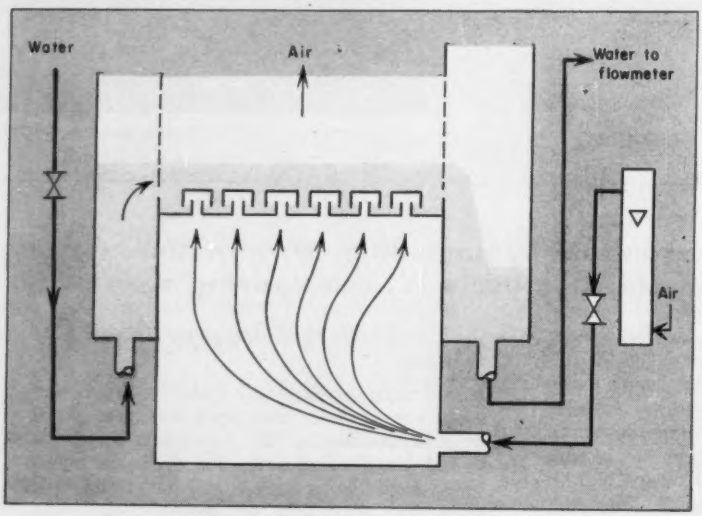
metering and proportioning pumps

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MAGNESIUM ALLOY SAND CASTINGS

How test chamber was built



How tray section was tested



the proposed tray design (*see sketches*). Test results with this segment checked well against the anticipated service conditions.

▶**Radial Liquid Path**—The 4-in. tray spacing required that liquid submergence on the tray be kept extremely low and that the slot opening or slot velocity be a small fraction of that used in conventional chemical and refinery towers.

Low submergence was obtained by radial flow design. Alternate trays have central downcomers; their mates have peripheral downcomers. Length of liquid path is a minimum, presenting the lowest possible gradient, and weir lengths are at a maximum.

Vapor velocity through the cap slots had to be so low that slots would be blown open not more than 0.3 in. This dictated use of tiny caps. The 1-in.-dia. caps were considered optimum size, since they provided so much slot area that the tower vapor capacity was nearly equal to that of a tower using 3-in. or 6-in. caps on 12-in. tray spacing.

▶**Nitrogen Wash Tower**—Hydrogen for Atlantic's ammonia production comes as a byproduct of its nearby refinery operations. After a preliminary caustic wash, the hydrogen stream is purified by scrubbing with liquid nitrogen at about −290 F.

Trays of the nitrogen wash tower are spaced at 8-in. intervals. In comparison to the 4-in. spacing and high purity specifications for the air fractionator, the design of these trays was considered far less critical.

Borden Doubling Its West Coast Formaldehyde

With a Seattle, Wash., plant to be completed late in 1956, the Borden Co. will double its West Coast output of formaldehyde. New production will come to 36 million lb. per year. The company already manufactures and sells about 10% of the formaldehyde used in this country.

Chemico-Metals Wave Hits Salt Lake

Cobalt, tungsten and uranium figure prominently in an unusual amount of chemical industry news coming out of Salt Lake City, Utah.

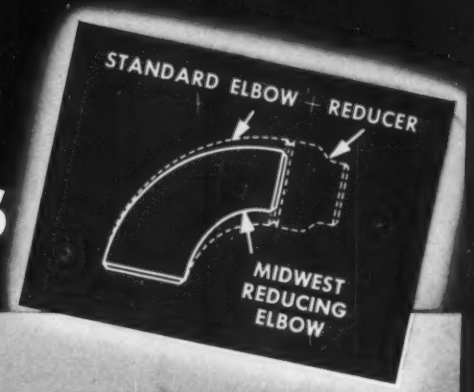
• Re cobalt: Chemical Construction Co., having demonstrated commercial workability of its high-pressure, high-temperature chemical reduction process for refractory cobalt ores at Howe Sound Co.'s Garfield, Utah, cobalt refinery, has just turned its operation over to the owner. This may signal the coming-of-age of the Chemico-developed process.

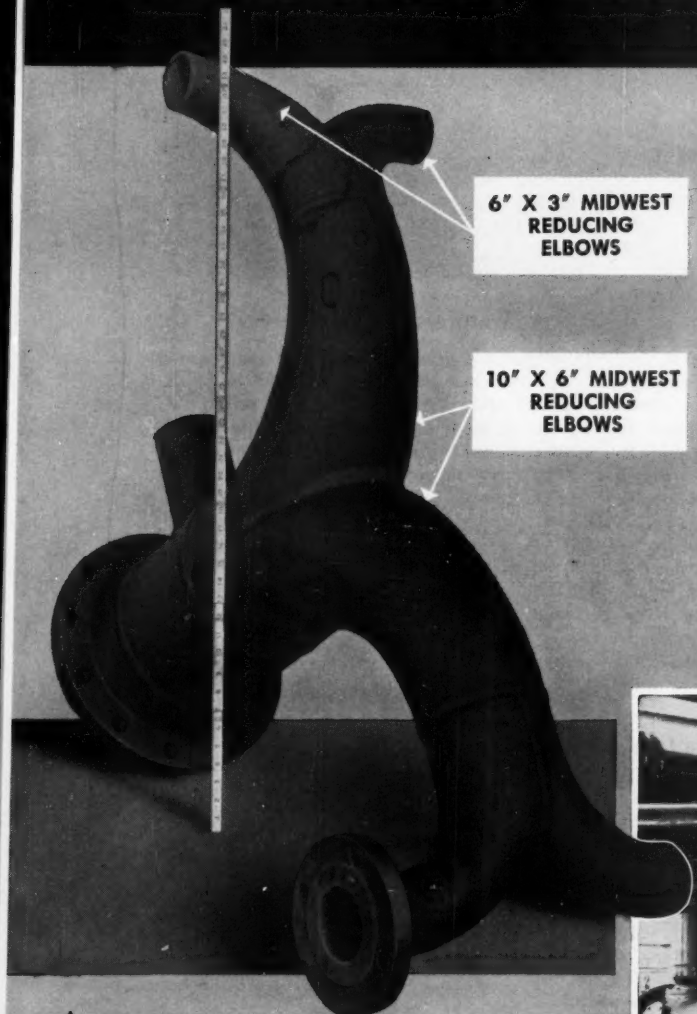
Heralded in 1950 as the new look in metallurgy for copper, cobalt, nickel and manganese, it has been subject to numerous setbacks during attempts at commercialization at Garfield and at a National Lead Co. facility in Fredericktown, Mo.

Both Chemico and Howe Sound have stated that prob-

Better Piping at a Better Price

by Using MIDWEST REDUCING ELBOWS

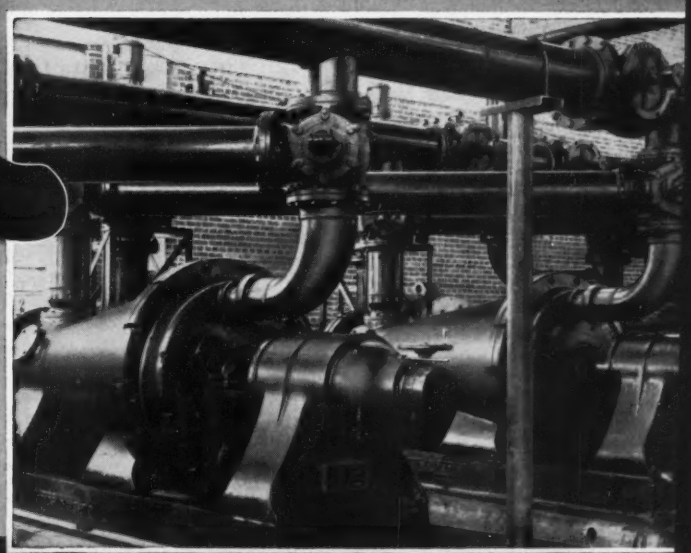




The Midwest Reducing Elbow offers important advantages in both piping design and piping cost. It needs only two welds instead of the three required by a standard elbow and a reducer (see sketch above). There is also a saving in layout time. Turbulence and pressure drop are reduced by the gradual taper . . . less space is needed . . . insulation is easier . . . and piping appearance is improved.

Only Midwest Reducing Elbows are available from stock in sizes to 16" . . . larger on special order. They have the same dimensional accuracy, uniformity of wall thickness, exact included angle and true center-to-end dimensions of Midwest Straight Elbows. For further information, ask for Catalog 54.

699



↑ Midwest Reducing Elbows made it possible to fabricate this transformation piece for a boiler feed suction line so that it could be installed in the limited space available and still get the benefit of streamline flow. There was also a cost saving in comparison with a less efficient and bulky assembly made with straight tees, ells and reducers.

→ Paper stock flows with minimum resistance through Midwest Reducing Elbows from 8" connection on Jordan to 10" header. Other advantages over standard elbow and reducer: a saving in cost and space, and improved appearance.

MIDWEST WELDING FITTINGS
Improve Piping Designs
and Reduce Costs

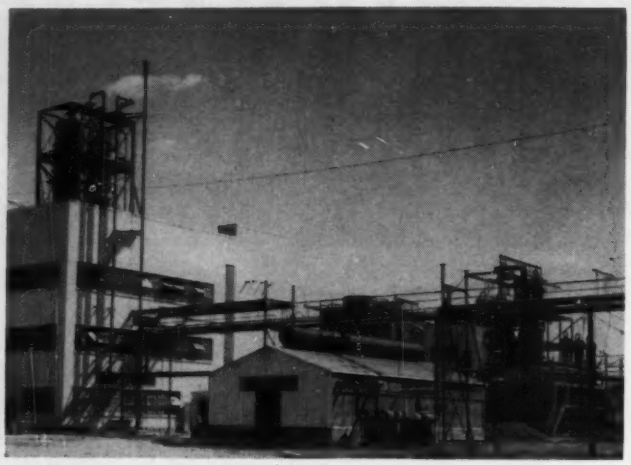
MIDWEST PIPING COMPANY, INC.
Main Office: 1450 South Second Street, St. Louis 4, Mo.
Plants: St. Louis, Passaic, Los Angeles

lems were mechanical rather than metallurgical. And after exhaustive technical survey, Battelle Memorial Institute found that the process was sound. Some past problems which have now apparently been circumvented or compensated: Specially designed stainless steel valves and fixtures had to be installed after the Garfield plant was completed; production of byproduct ammonium sulfate was dropped because it contained too much cobalt.

• As for tungsten, Salt Lake Tungsten Co. has started up its new Salt Lake City plant producing high-purity ammonium paratungstate. It excels artificial scheelite (calcium tungstate), now made by SLT and other U.S. tungsten refiners, in easy convertibility to powdered tungstate for direct use in the metallurgical trade. At that, some end-refining operations required for scheelite can be skipped in processing ammonium paratungstate. And by making a purer product, the company hopes to compete more handily with foreign-produced tungsten ores refined in this country.

• In uranium: A western location—possibly Salt Lake City—is sought by a number of the major companies preparing to bid on construction and operation of a new uranium salts refinery proposed by AEC. The city fills several important requisites for location of the proposed $6-8 million, 5,000-ton-per-year facility: nearness to hydrofluoric acid supply and to domestic uranium concentrates; and AEC's demand for dispersion of industry.

• More Salt Lake City activity: A salt-harvesting plant will start up nearby this spring by Chemical Salt Production Co., jointly owned by Hooker Electrochemical Co. and Pennsylvania Salt Mfg. Co. Also, an alunite rock crushing plant has been placed in operation at Marsvale, Utah, by Alunite Corp. of America. The potash-containing mineral is shipped to Salt Lake City for blending with ammonium sulfate in the manufacture of a combined fertilizer and soil conditioner.



Peroxide Plant Uses New Nonelectrolytic Process

A new Syracuse, N. Y., plant of Allied Chemical & Dye Corp.'s Solvay Process Div. has just started producing hydrogen peroxide by a new nonelectrolytic process. The company-developed process is described only as a chemical oxidation; it uses hydrogen from Solvay's adjacent electrolytic chlorine-caustic plant. Both 35 and 50% grades of peroxide are produced. Other companies which have followed Du Pont into the nonelectrolytic peroxide field: Becco Chemical Div. of Food Machinery with a process of its own (Chem. Eng., Aug. 1955, p. 108) already in use at a new Buffalo, N. Y., plant; Shell Chemical Co. and Columbia-Southern Chemical Corp., each with plans for commercialization of nonelectrolytic processes.

Transistors Made New Way Fit for New Uses

A transistor which can operate at frequencies high enough for home television sets and another one 10,000 times more sensitive to light than a conventional photoelectric cell, yet able to control 100 times more current, have been developed by Westinghouse Electric Corp. They're the result of a new manufacturing process which allows the critical *n*-layer of the *p-n-p* germanium junction to build up to optimum thickness and uniformity instead of being inexactly dissolved away, as in conventional methods.

The first type works at frequencies far above those encountered in hearing aids and radios, where transistors are now finding general use. And the second (which can operate a standard relay without amplification on a voltage as low as that from a 1½-v. dry cell or a 6-v. storage battery) suggests itself for such uses as simplified and improved automatic headlight dimmers on autos.

More Cement From Four Sources

Three expansions and a new plant under consideration have been added to the roster of plans for increasing the nation's cement capacity. The expanders: Pittsburgh Coke & Chemical Co., at its Neville Island facilities near Pittsburgh; Lehigh Portland Cement Co., boosting by one-third the capacity of its Mason City, Iowa, plant to reach 3 million bbl. by 1957; Ideal Cement Co., spending $6 million to double present 1.3-million-bbl.-



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per-year capacity of its Okay, Ark., plant. Riverton Lime & Stone Co. is considering construction of $10-million portland cement plant at Riverton, Va., with an annual production capacity of 1.5 million bbl.

Du Pont Upping Output Of Paint Ingredients

Du Pont will increase its production of polyvinyl acetate emulsion, used primarily in paint making. A $550,000 project to expand polyvinyl acetate emulsion capacity at Niagara Falls is scheduled for completion late in 1956.

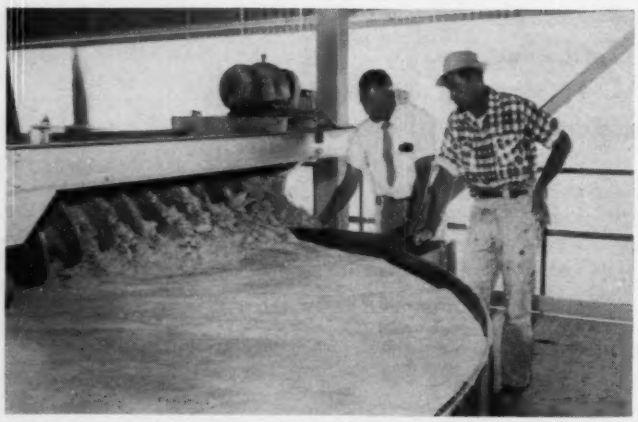
Furthermore, the company plans expansion of Edge Moor, Del., and Baltimore plants to produce more titanium dioxide, the white pigment widely used in paint, paper and plastics and currently in short supply. When completed in 1957, these additions—plus one previously announced for Edge Moor—will boost the company's output by more than 25%

Atomic Aid in Getting Oil From Tar Sands

Need for an easy way to compute settling time of solids in oil-sand emulsions has, until now, retarded progress in developing the hot-water method for extracting oil from Canada's rich-but-reluctant tar sands. Now Alberta Research Council engineers have used small radioactive steel balls to collect data on which to base a general settling-time equation. The equation predicts quickly and accurately how soon sand-free product will be ready for refining or transportation through pipelines.

To develop the equation, researchers dropped small radioactive steel balls through opaque oil-sand emulsion in containers with Geiger counters mounted at top and bottom. Electrical recorders signalled the times at which the balls went past each counter.

The new device will also be a help to refiners and pipeline operators handling heavy oils.



Rotating Filter Dryer at New O-I Silica Sand Plant

Moisture reduction in silica sand, mined by Owens-Illinois at a new sand plant in Ione, Calif., takes place in a rotating filter, from which sand is removed by scroll conveyor and taken to storage bins. Before this step, maze of wet-milling machinery removes clay from the sand, which goes on to classifying, flotation and more classifying. After final processing in an oil-fired dryer, finished product is finer than granulated sugar, almost as white as chalk.

News Briefs

Aluminum sulfate: Allied's General Chemical Div. will complete a new liquid aluminum sulfate plant at Hopewell, Va., this spring.

Asphalt: Texas Asphalt & Refining Co. plans a $1-million, 2,500-bpd. asphalt refinery at Pasadena, Tex., for completion by mid-1956.

Resorcinol: Koppers Co. is expanding its Petrolia, Pa., plant to bring about a 40% increase in production of resorcinol.

Polyvinyl chloride: A $500,000 plant for polyvinyl chloride resin is being built by Thompson Chemical Co. at Hebronville, R. I. Completion is set for fall.

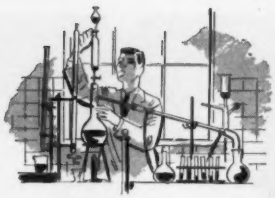
Parathion: American Potash & Chemical Corp. has almost completed facilities for captive production of technical parathion at Richmond, Calif.

Methyl ethyl ketone: Shell Chemical Corp. has started construction on a MEK plant at Norco, La., with a capacity of 40 million lb. per year.

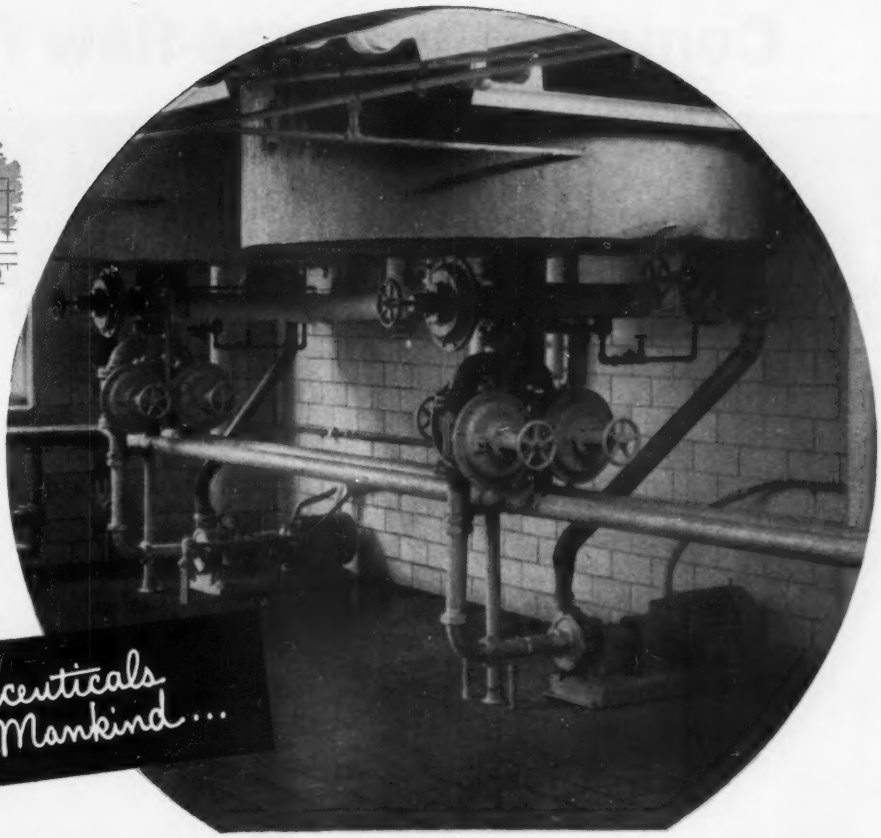
Formaldehyde: A formaldehyde plant, which may well be the world's largest, has been reactivated by Merck & Co. in Danville, Pa. Built by the government in 1942 and in standby condition when Merck bought it in 1950, it has now been completely modernized.

Orlon and nylon: Du Pont has announced that it is studying the possibilities of a large new Orlon acrylic fiber plant in Waynesboro, Va., and a large nylon plant in Richmond, Va.

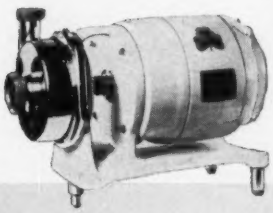
Paper: MacMillan & Bloedel Ltd., British Columbia forest products firm, is adding an $18 million facility to its $40 million pulp and paper mill at Port Alberni. It will double the 300-ton-per-day newsprint output at the Vancouver Island operation.



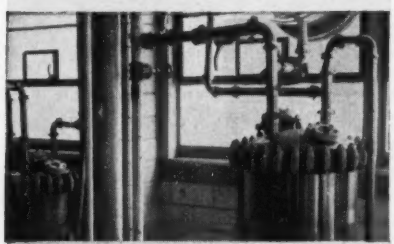
(Right): Tri-Clover stainless steel pumps handle an important liquid conveying job in this pharmaceutical plant.



...produced with TRI-CLOVER Pumps, Fittings and Valves



One of a complete line of Centrifugal Pumps designed by Tri-Clover. Full details on these modern, efficient units are contained in the complete Tri-Clover Sanitary Pump Catalog 253. Write for your copy.



Both standard acme thread and Tri-Clamp stainless steel fittings and valves are utilized in these liquid process lines.

The scenes depicted here show some of the Tri-Clover pumps and stainless steel fittings and valves now being used by a modern midwest pharmaceutical plant. Tri-Clover supplies the vital elements necessary to provide a "streamlined" processing line with the greatest possible degree of corrosion-resistance and sanitation. This is a typical example of the way Tri-Clover products are used to help solve numerous liquid conveying line and pumping problems for the chemical process industries.

For pumping applications, Tri-Clover supplies corrosion-resistant centrifugal pumps designed to handle, efficiently and economically, any product that will flow to them. For process lines, Tri-Clover fittings and valves are widely used to assure the utmost protection against corrosion and product contamination.

Take advantage of Tri-Clover's exclusive features developed through many years of specialized engineering experience and thorough understanding of liquid conveying problems.

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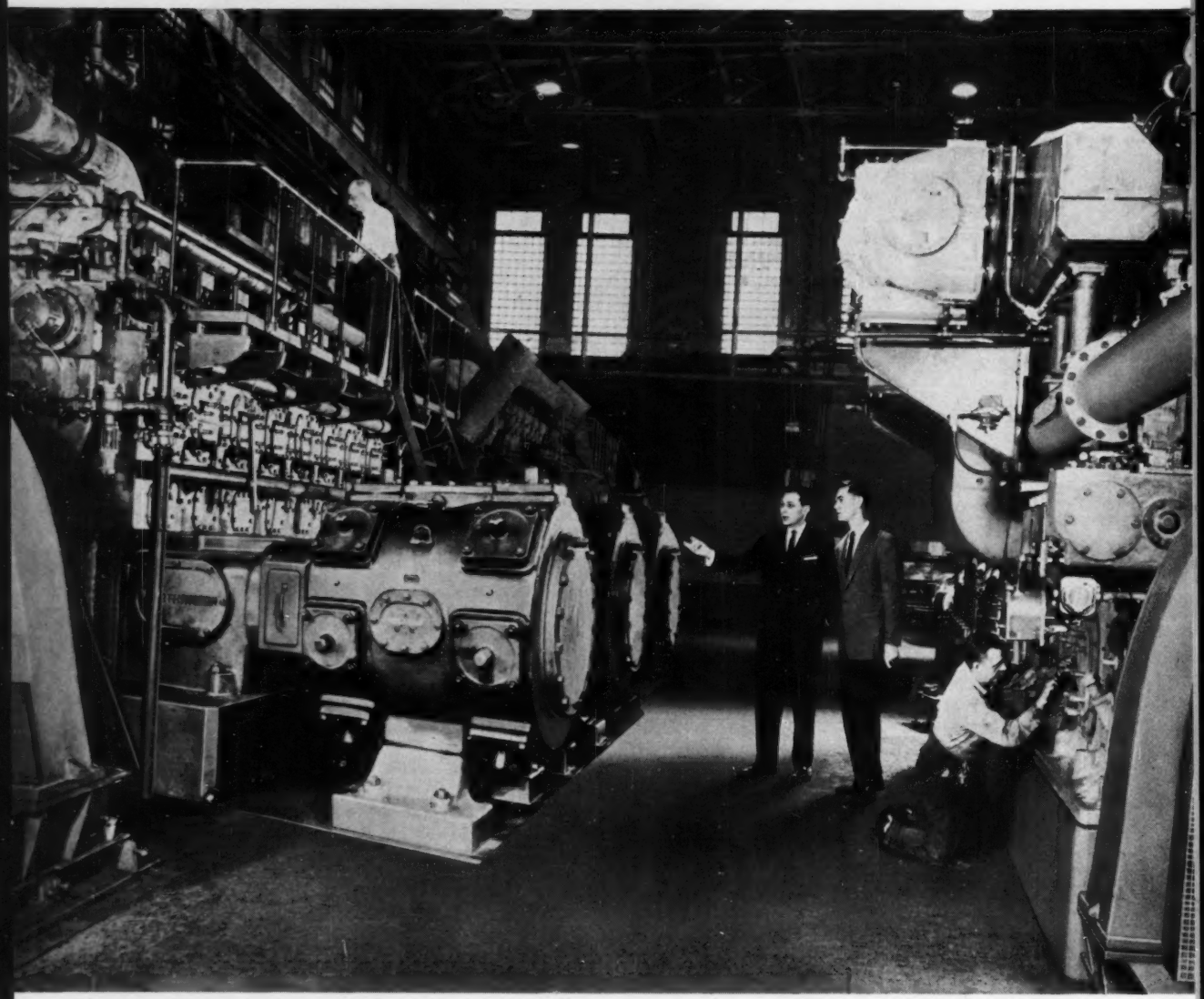
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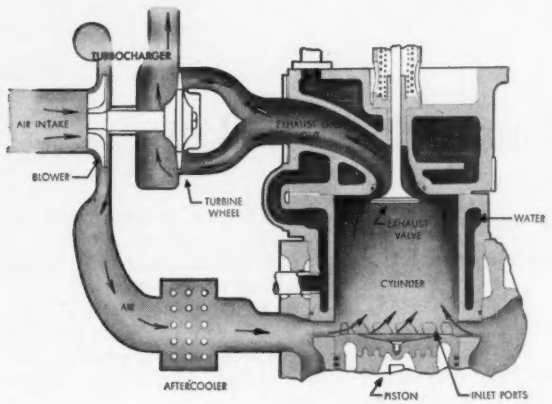
The only turbocharged 2-cycle engine compressor with

with 2-cycle compactness...

NO POWER-DRAINING EXTRA DRIVE FOR SUPERCHARGING WITH THE "TURBO-UNIFLO"— WORTHINGTON'S SUTC GAS-ENGINE COMPRESSOR

In its first production year this unique two-cycle turbocharged gas-engine compressor (750 to 2500 hp) has had remarkable process industries acceptance. Designed for quiet exhaust-powered pulse-type turbocharging on the basis of Worthington's extensive two-cycle engine-compressor experience, more than twenty-four TURBO-UNIFLO SUTC's are either installed or on order.

By integrating exhaust-powered turbocharging with field proven Worthington Uniflo scavenging design, Worthington engineers have developed a two-cycle engine-compressor unequalled for stability of performance over the *complete* range of speed and load requirements. Operating at relatively high compression ratio, the TURBO-UNIFLO has much smoother combustion characteristics than other engines with lower compression ratios. This is due to the basic timing arrangement, engine configuration, and design of exhaust manifolding. Sufficient exhaust gas energy is applied at the turbocharger, from engine start-up through all speeds and loads, to give full turbocharged effect without added external mechanical means for driving the supercharger. Low fuel and lube oil consumption are other advantages.



TURBO-UNIFLO OPERATION — Exhaust valves are timed to open and generate a pressure pulse to move the turbine blades. This gives self-sustained starting and quick acceleration without external aid or mechanical drive. Blower delivers air under pressure to the aftercooler. Cooled air enters the cylinders through inlet ports 360° around the liner. During the scavenging period, the combustion chamber walls and valves are effectively cooled.

The Uniflo system is accepted as having highest scavenging efficiency. It also gives the best turbocharging-scavenge ratio due to complete absence of residual gases in the combustion chamber.

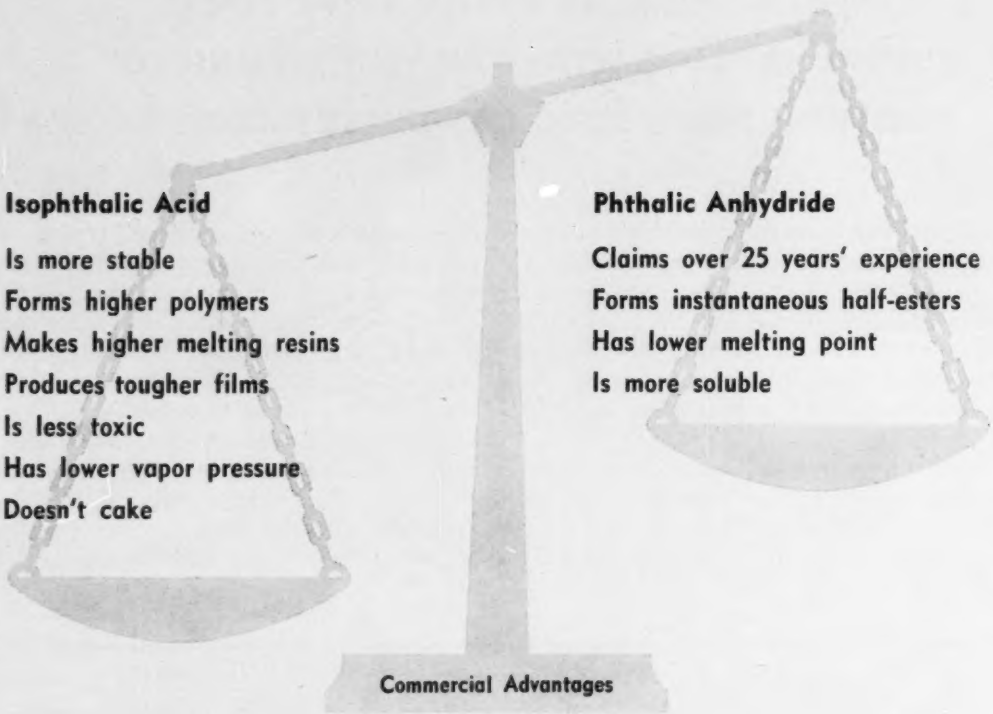
QUIETER OPERATION. Cast-iron exhaust manifolding—dry insulated, built-in air-pulse dampener, triple-strand silent camshaft chain, hydraulic valve lifters and elimination of any mechanically-driven air charging device assure quietness.

FEATHER VALVE. The feather valve is standard TURBO-UNIFLO equipment. It's the lightest, simplest and quietest valve—and operates with no impact!

For more details on the TURBO-UNIFLO, call your nearest Worthington District Office, or write Worthington Corporation, A&SP-Engines, Harrison, New Jersey.

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exhaust-powered turbocharging from start-up through full-load



Isophthalic Acid Challenges PA Markets

This 50 million-lb./yr. challenger seeks to make inroads on phthalic anhydride's easy-to-sell production rate of over 340 million lb./yr.

A brand new industrial chemical came on the market early in January when Oronite Chemical Co. shipped the first carload of isophthalic acid from its $10 million, 50 million lb./yr. plant at Richmond, Calif.

To some phthalic anhydride users, that carload signaled the end of an era—the end of almost continual shortages or near-shortages. For it seems certain that at least initially a goodly share of Oronite's output will go to traditional PA users—alkyd resins, saturated and unsaturated polyester plastics and plasticizers, etc.

Oronite, subsidiary of Standard Oil of Calif., is the only producer of all three xylenes (ortho, meta and para) and no newcomer to the xylene-based acid picture. Since 1945, it has been marketing its own phthalic anhydride—to the tune of about 14 million lb./yr. And it isn't about to abandon those sales. But eight years of laboratory and development work have convinced the company that the future lies with isophthalic acid.

Basis for Oronite's optimism is the superiority of isophthalic over phthalic anhydride:

- Shows greater heat and chemical stability.
- Makes harder, higher melting resins.
- Produces tougher films.
- Forms higher polymers with alcohols and amines.
- Has lower vapor pressure.
- Doesn't cake.
- Is less toxic.

Despite an anticipated rosy future, few market men, even at Oronite, care to estimate IPA's eventual impact. Seldom has a new product been introduced with a production capacity as high as 15% of the record market for the long-established, older product it hopes to replace.

And with other companies eyeing possibilities for isophthalic acid, Oronite's infant iso might itself face upstart compe-



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Plastic-coating process 146B
Resin coating for plant maintenance.....148A
Fire-resistive mastic 148B
Phosphate insecticide 148C
Tissue-like glass paper.....148D
Epoxy plasticizer 150A
Methyl vinyl ketone.....150B
Didecyl adipate plasticizer 150C
Rare earth oxides.....150D
Coagulant aids 150E
Nylon cement 150F
Fire-resistant synthetic oils.....150G
Teflon dry lubricant 150H
Dialkyl methyl tertiary amines.....150I
Synthetic heavy-duty yarns.....150J

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tition before too long. For example, Standard of Indiana (with an interest in Scientific Design's process), Hercules and Richfield Oil are all involved in xylene oxidation activity.

▶**Superior Thermal Stability**—Isophthalic acid's superior thermal stability gives it a double edge over PA—in alkyd resin processing and in resin stability.

Alkyd resins based on isophthalic can be processed at higher temperatures (maximum 525-575 F.) than PA-based resins (maximum 450-475 F.) to give lighter color, higher molecular weight products. Also, larger amounts of low-cost oils may be used, since oil-bodying may be practiced. For while PA resins with oil lengths greater than 75% fall apart at temperatures over 475 F., with isophthalic acid oil lengths can be built up to 90%. And with stability at higher temperature, the unsaturated double bonds can be thermally cross-linked instead of waiting for the normal drying process using oxygen uptake to do the job. Finally, use of low-cost tall oil fatty acids becomes practicable because elimination of the undesired natural drying inhibitors occurs at the elevated temperatures permitted with isophthalic.

As for stability of formed resins, Dow Corning Corp. has found isophthalic-based polyester resins to be about 40 times as stable as similar resins made with PA. This stability permits faster production schedules in baking lines, superior heat stability in plasticizers and wire coatings for electrical insulation and, in general, gives better results in all high temperature work.

▶**Good Chemical Stability**—Isophthalic-based resins show marked hydrolytic stability and resistance to mild alkali. Oronite speculates that this stability may give alkyd oil-based emulsion paints a much-needed shot in the arm, making them practical enough to overcome inroads that higher priced, more stable latex-based paints have been making on their markets.

"Setting-up" or gelling of paints in their containers due to reaction of resins with reactive pigments will also be markedly reduced because of isophthalic resins' chemical stability.

▶**Harder, Higher Melting**—In general, isophthalic has been found to give harder resins than phthalic anhydride at comparable compositions, reducing need for more costly amine resins to obtain the desired final coating hardness.

In addition, isophthalic resins are higher melting; in unsaturated polyesters, they may be ground and stored as dry powder until solution in styrene is needed for application—thus preventing any chance of gelling in solution. Powdered PA-based unsaturated polyesters, on the other hand, fuse together on storage at normal temperatures and have limited storage life in styrene solution. In films, isophthalic-based resins give a highly desirable toughness and flexibility even at considerably longer oil lengths than PA resins, primarily because of higher molecular weights obtainable with isophthalic.

▶**Higher Polymers**—In highly technical language, "The higher molecular weights are possible because of the complete availability of difunctional properties due to the absence of intracyclic ester and imide formation," one Oronite product development man says with a grin. It is in this high molecular weight field that Oronite is looking for markets where phthalic anhydride is not competitive.

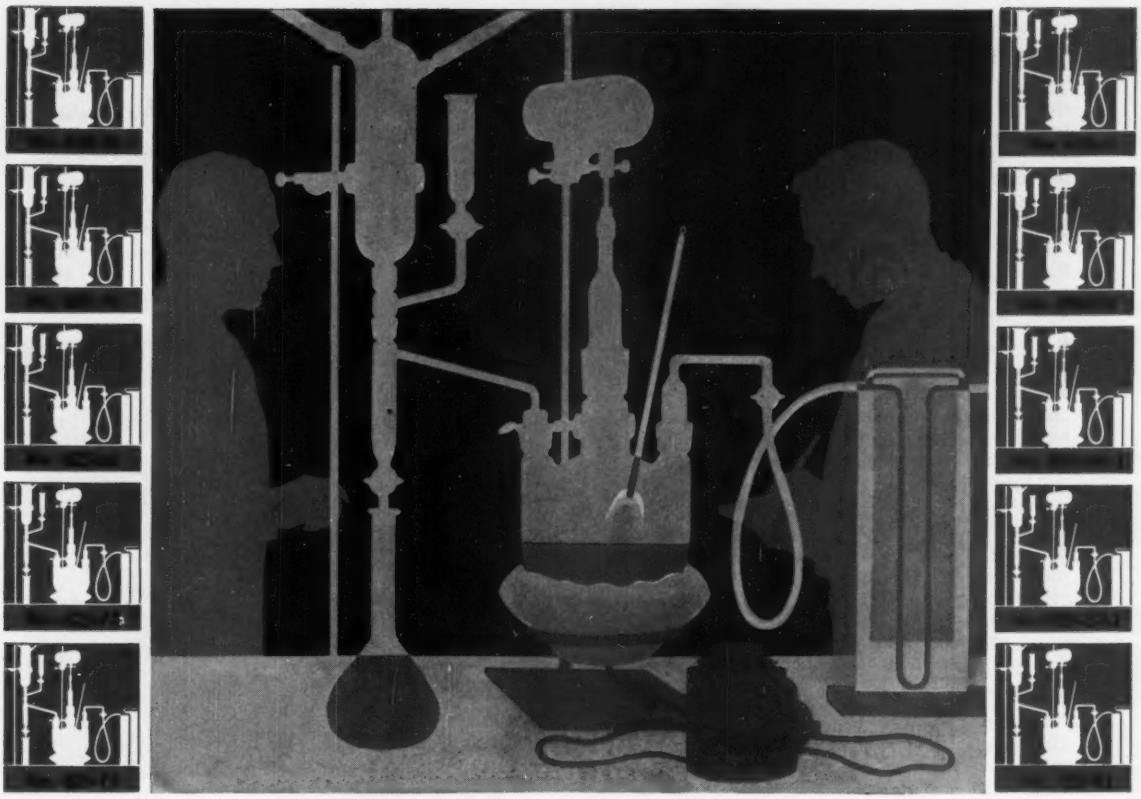
Behavior of isophthalic acid in the preparation of high polymers is similar to the more expensive dimethyl terephthalate. Extremely interesting copolyster-amide products can be made from isophthalic, holding great promise in adhesives and molding applications. IPA is also receiving a hard look as a new, reasonably-priced intermediate for derivatives where the meta structure gives desirable properties.

Two other differences between IPA and PA make isophthalic attractive. First, isoph-

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thalic's lower vapor pressure is important because of increasing air pollution consciousness of the country; it could be used in equipment and areas in which PA would cause grave pollution problems. And isophthalic's non-caking property is an added plus in handling, packaging and shipping.

▶ **Lower Toxicity**—Phthalic anhydride's toxicity (LD_{50} of 6.0 g./kilo in mice) and the fact that free PA is liberated during baking has apparently discouraged the resin industry from applying for Food & Drug approval of PA resin can linings. IPA's 50% lower toxicity (LD_{50} of 9.4 g./kilo) compared to PA may lead to federal approval and ultimate use of isophthalic resin linings in the food industry. There is no doubt that physically the resins would measure up to specifications.

▶ **Biggest Potential**—In general, isophthalic acid should find its biggest market in alkyd paints (for both industrial and architectural finishes). Promising isophthalic vehicles in the architectural field include new alkyd stain- and blister-resistant paints and the tougher, more flexible exterior and interior enamels. Alkyd flat paints based on IPA also appear promising. In the industrial field, isophthalic will be used in automotive enamels to give superior gloss retention and in appliance finishes for improved whiteness and alkali resistance.

Smaller, but significant, consumption of IPA is expected in unsaturated polyesters (1955 production topped 60 million lb./yr.) and in plasticizers (currently consuming about 100 million lb./yr. of PA).

In the unsaturated polyester field, isophthalic contributes increased strength, heat distortion and toughness to reinforced plastic. High heat distortion, impact and flex strength of isophthalic polyesters are maintained over a wide range of styrene dilution. This ability to use larger amounts of styrene than with phthalic anhydride resins helps IPA over its largest hurdle in the unsaturated polyester field—high cost.

About 75% of Oronite's production will be marketed in the East, with heavy consumption on the East Coast and in the Ohio Valley. IPA will be shipped from California to the East Coast by freighter in palletized bags.

▶ **PA Not Overlooked**—In the meantime, Oronite isn't burying its head in the sand regarding phthalic anhydride. Initial price difference (currently iso at 23¢/lb., freight equalized with PA; phthalic anhydride at 20¢/lb.) is the first big hurdle isophthalic must overcome. Also with over 25 years of successful industrial application and study of PA, many of the problems encountered in the very complex resin field have been worked out. Moreover, phthalic anhydride melts to give a quick reacting liquid at processing temperatures and since it is an anhydride, half-ester formation is instantaneous.

Surprisingly, too, lower functionality or reactivity of phthalic anhydride which hinders high polymer formation becomes an asset in preparation of short oil length alkyd resins. These have a tendency to "gel" before ester formation is sufficiently complete to give good durability to the resin. But reduction of isophthalic's reactivity in such resins (and of PA, when necessary) may be accomplished by use of monobasic acids such as benzoic. And Oronite will produce a coproduct mixture of benzoic and *m*-toluic acids (80-90% benzoic) from its isophthalic plant priced at 20¢/lb. or lower to permit reasonable cost modification of reactivity in short oil alkyds (and to help take the sting out of isophthalic's 3¢ premium). 142A

Monopentaerythritol

Highly pure monomer, has zero ash content.

Good news for alkyd resin and explosives manufacturers is the recent announcement that monopentaerythritol is now available in a high grade of purity.

A new process for monomer manufacture removes both inorganic and organic impurities. Elimination of inorganic impurities (referred to as ash content) makes it easier to obtain uniform properties in products made from mono-PE. And removal of organic impurities (e.g., PE polymers) increases the pure monomer content.—**Hercules Powder Co., Wilmington 99, Del.** 146A



Plastic-Coating Process

Can coat metals, ceramics, glass, wood with a variety of materials.

Believed to be the first process of its kind to be introduced into the U. S. is Whirlclad, a patented German process for coating metals, ceramics, glass and wood with various plastic materials.

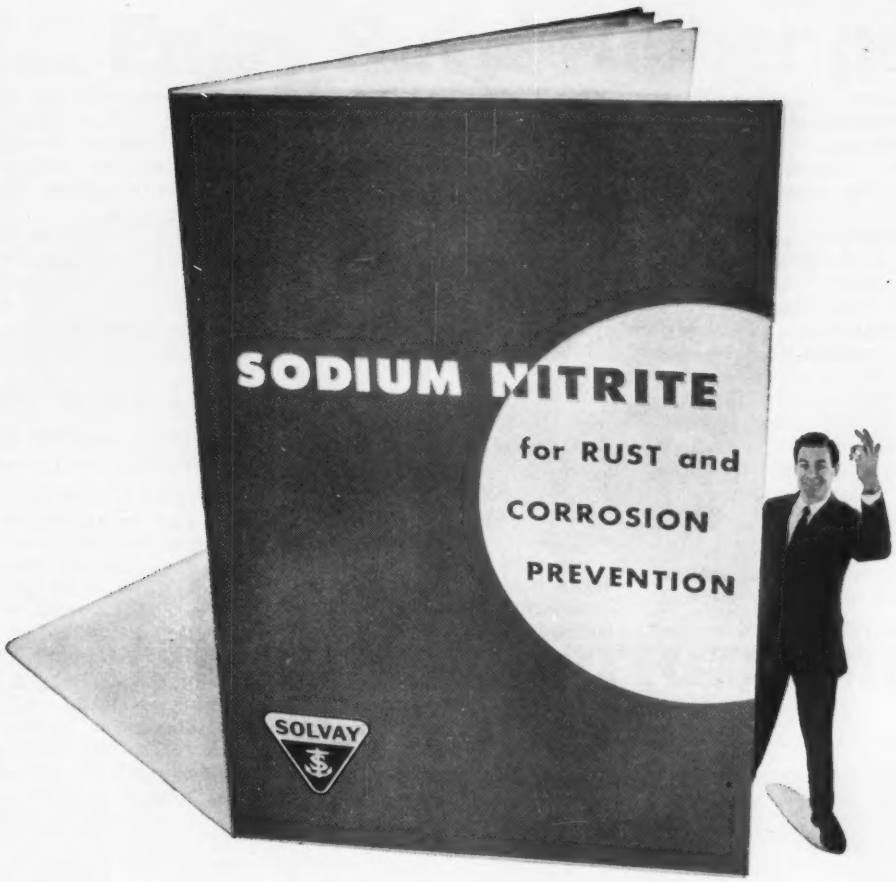
Two biggest claims for the new technique:

- Combines natural advantages of plastic coatings with the parent material to be coated.
- Makes use of coating materials which, heretofore, have never been satisfactorily applied.

Briefly, Whirlclad consists of dipping (*see cut*) preheated articles in a fluidized bed of solid, finely divided plastic (containing some minor modifying agents, but neither plasticizer nor solvent).

The melting point of the material to be coated must be higher than that of the coating. And for best adhesion, the surface of the article should be roughened by blasting with angular shot.

To date, Whirlclad has been extensively used with nylon and



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The new edition of this book may prove extremely helpful to anyone interested in the prevention of rust and corrosion.

This new book describes how SOLVAY Sodium Nitrite is being used, alone and in combination with other materials, for the cleaning, neutralizing and protection of metal in such diverse applications as: cargo holds of ocean-going tankers in light petroleum service; steel scouring pads; machined parts in process; steel forms such as sheets, pipes and wire; metal tanks and containers; and circulating water systems.

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low-pressure polyethylene as the coating mediums. But other materials—e.g., polystyrene, cellulose acetate, butyrate, acrylics and epoxy resins—can be used.

The new process is said to produce evenly distributed, uniform coatings on the base material, including irregular shaped objects and pipe interiors. A standard licensing program has been set up for those companies desiring to do their own coating in large production quantities.—**Polymer Processes, Inc., Reading, Pa.** 146B

Resin Coating

Cuts cost, labor in maintenance of masonry surfaces.

Though specifically developed for the railroad industry for maintenance of wood floors and walls of freight cars, Glid-Iron, a 100% solids resin coating is expected to have unlimited possibilties as an industrial maintenance material.

Points in its favor:

- Adheres to wood, metal, concrete.
- Resists chemical attack, shock and impact.
- Smooths out and bridges small cracks.
- Sets to a hard, tough, flexible, scuff-resistant finish after curing overnight at room temperature.
- Withstands extreme temperature ranges—from −20 to +212 F.

Glid-Iron can be applied by spray, brush, roller or squeegee to any mil thickness. Application time for a 10x40 ft. area is 20-30 min. with an undercoating gun and 2-4 man-hr. by other methods.

Floor coating is skidproof even when wet. And nails can be driven through the film without chipping it.

Application cost of the new coating is 15-19¢/sq. ft., compared with other techniques ranging to 35¢/sq. ft.—**Glidden Co., Cleveland, Ohio.** 148A



Unlike Most Mastics, New Coating Resists Ignition

Designed to eliminate plant fires caused by ignited mastic coatings is fire-resistive mastic 60-60N, a combination of non-asphaltic fibrated polymers in nonflammable solvents.

The new mastic is nonflammable in the wet state; when dry and exposed for two minutes to violent kerosene flame, it stops smoldering within seven seconds after removal from the flame. Dry film retains maximum flexibility and chemical resistance indefinitely. And heat resistance is excellent for prolonged periods.

As an insulation coating, 60-60N is an excellent vapor barrier, with a vapor permeance of 0.02 perm. It's supplied in natural resin color or in aluminum, can be painted over without a sealer.

60-60N is approved by Underwriters' Laboratories as fire resistive.—Benjamin Foster Co., Philadelphia, Pa. 148B

Phosphate Insecticide

First systemic to be effectively applied to seeds.

Thimet, a systemic insecticide, can be applied to seeds and enables plants to kill insects that feed on them.

Field tests show that when cotton seed is treated with Thimet (O,O-diethyl S-(ethyl thiomethyl) phosphorodithioate), the insecticide stays in the growing plant and continues to kill insects for periods up to nine weeks after the plant has come through the ground.

At present production costs, Thimet treatment of cotton seed will add about $3 per acre to the cost of untreated seed. But, such treatment would replace the 2-4 conventional spray applications to growing plants to control aphids, mites and other pests.

The new insecticide may be marketed—in limited quantities—to cotton seed dealers in Texas and Mississippi for treatment of seed to be planted for the 1956 crop.—**American Cyanamid Co., New York 20, N. Y.** 148C

Ultra-Thin Glass Paper

Combination of microglass fibers with, binder and/or plastic impregnation.

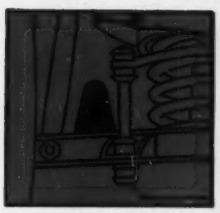
One of the latest additions to an ever-growing list of specialty paper products is Tissuglas, an ultra-soft, tissue-like film.

Available in thicknesses from 0.5-13 mils and widths to 40 in., this paper is a combination of microglass fibers to which a binder and/or impregnations can be added for desired electrical, chemical and thermal properties. When specified, the

In over 100 places, Enjay Butyl rubber parts



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Axle bumper



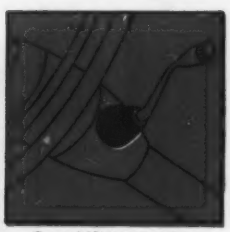
Body seals, gaskets, insulators, pads, grommets, etc.



Brake and accelerator pedal pads, bellows



Radiator and heater hoses, ducts



Gearshift lever cover

Pontiac has been using parts made of Enjay Butyl since 1946. The great '56 model now incorporates more than 100 parts made from this super-durable rubber, adding to its performance, style and value. These parts have amazing resistance to deterioration and will easily last the life of the car.

Among the many advantages of Enjay Butyl are *price* and *ready availability*. And it is now available in non-staining grades for white and light-colored parts. Extensive laboratory and testing facilities are at your service. For the full story, contact the Enjay Company today.

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Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture

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binder is insoluble in aqueous and most organic solvents. Successful impregnations have been made with melamine, epoxy, silicone, polyvinyl chloride, polytetrafluorethylene and polyester preparations.

Plain Tissuglas can be as much as 95% air by volume, thus providing industry with a carrier sheet composed of up to about 95% resin (balance: inert carrier). Wet strength is approximately 70% of dry tensile (95-880 psi.); breaking strength varies from 200-1,350 g./in. of width.

Potential applications: surfacing sheets for high- and low-pressure laminates; backing material for variety of volume-production sheet products, notably mica.—**Commercial Development Div., American Machine & Foundry Co., New York 16, N. Y.** 148D

Epoxy Plasticizer

Stabilizes lacquers, vinyls and rubbers against heat, ultraviolet light.

Marked alcohol solubility; higher viscosity; greater resistance to gasolines, aliphatic solvents and oils distinguish Estynox 308 from other epoxidized oils.

This new epoxy-type plasticizer stabilizes nitrocellulose, ethylcellulose, cellulose acetate butyrate, polyvinyl chloride, chlorinated and synthetic rubbers against heat and ultraviolet light. Specifically:

• Lacquers—Low concentrations of 308 in nitrocellulose lacquers produce hard, tough, non-yellowing films. It's also particularly suited to water-white lacquers, automotive finishes, printing inks.

• Vinyls—For low marring of lacquer and plastic surfaces as well as resistance to gasoline and oil extraction, 308 is claimed to be superior to other plasticizers.

• Rubber—308 provides low oil and gasoline extraction, good heat resistance, moderate low-temperate flexibility in oil-resistant synthetic rubber.—**Baker Castor Oil Co., New York 5. N. Y.** 150A

For More Information . . .



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.

BRIEFS

Methyl vinyl ketone, a highly reactive chemical intermediate for manufacture of plastics, adhesives, drugs and chemical specialties, is being offered through a new commercial outlet. Manufacturer claims that its stabilized ketone can be stored for appreciable lengths of time without any noticeable change in properties. Ketone is available in 55- and 5-gallon steel drums.—**Chas. Pfizer & Co., Inc., Brooklyn 6, N. Y.** 150B

Flexol plasticizer 10-A (didecyl adipate) offers reduced volatility, improved resistance to water extraction and ability to impart excellent low-temperature flexibility and light stability to vinyls. 10-A can be used in calendered film and sheeting, dip coatings, electrical insulation, as a plasticizer for nitrocellulose, softener for both synthetic and natural rubber. Price: 42.5¢/lb. (tank car).—**Carbide and Carbon Chemicals Co., New York 17, N. Y.** 150C

Rare earth oxides—15 in all—are available in purities ranging from 99-99.98%, with lower purities available on demand.—**Research Laboratories of Colorado, Inc., Newtown, Ohio.** 150D

Coagulant aids improve efficiency of coagulants in removing turbidity from water. Aids cause flocs of aluminum or iron hydroxides to form more quickly, settle more rapidly. They also allow for clarification of raw water over a broader pH range than would otherwise be possible. Choice of three available compositions—No. 7, 11, 18—depends on water quality and type of clarifier or softener.—**Hagan Corp., Pittsburgh, Pa.** 150E

Nylon cement, Nylosil, requires no curing, can be had in a wide range of viscosities. Cement bonds possess all the strength and characteristics of nylon itself, are effective over a wide temperature range. Nylosil is highly resistant to oils, aromatics, aliphatic solvents, alkalis and bleaches—**Ions Exchange Corp., New York 13, N. Y.** 150F

Series of fire-resistant synthetic oils (Cellulubes) has been expanded to include hydraulic fluids and lubes in six controlled viscosities—90, 150, 220, 300, 500 and 1,000 SUS seconds at 100 F.—**Chemical Div., Celanese Corp. of America, New York 16, N. Y.** 150G

Teflon dry lubricant can be applied in a thin film—only a few ten-thousands of an inch thick. Used as a combination dry lube and corrosion preventative, it's serviceable from -75 to +500 F.—**Naval Research Laboratories, Washington, D. C.** 150H

Dialkyl methyl tertiary amines—Armeen M2HT, Armeen M2C and Armeen M2S—are proving of extreme interest as intermediates for synthesis of dialkyl quarternary ammonium compounds. Drum quantities of all three amines are available.—**Market Development Dept., Armour and Co., Chicago 9, Ill.** 150I

Caprolan heavy-duty yarns, based on polycaprolactam, are specifically geared for industrial applications and mechanical goods where toughness and impact strength are essential. Yarns have a minimum average standard tenacity of 6.5 g. per denier, will retain 90% of their strength in the wet state and will eventually be available in range of 2,000 to 50,000 total denier.—**National Aniline Div., New York 16, N. Y.** 150J

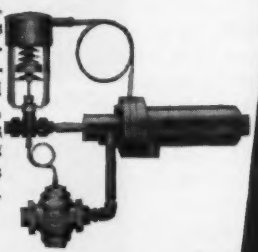
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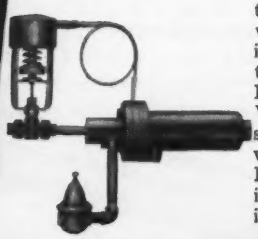
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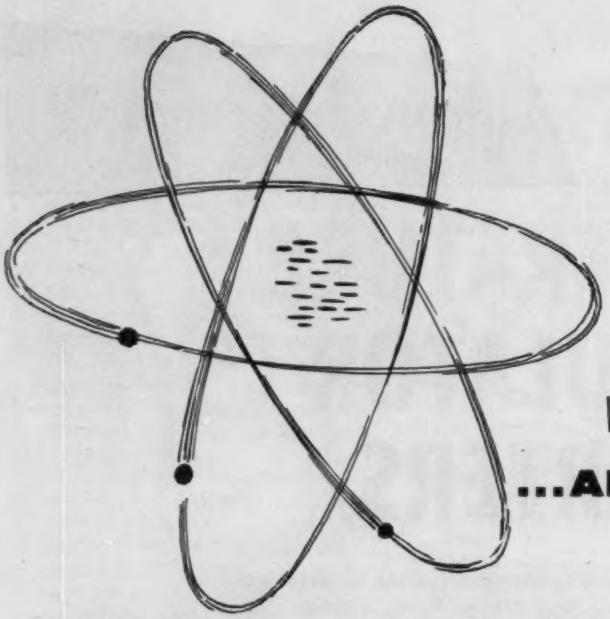
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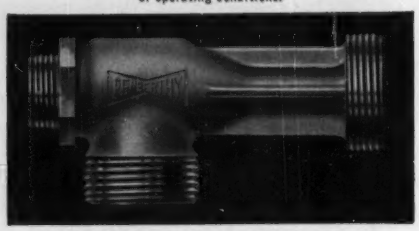
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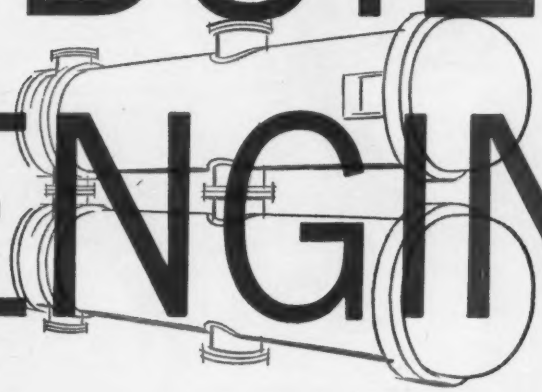
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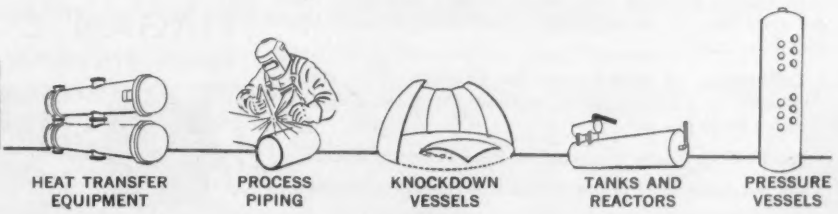
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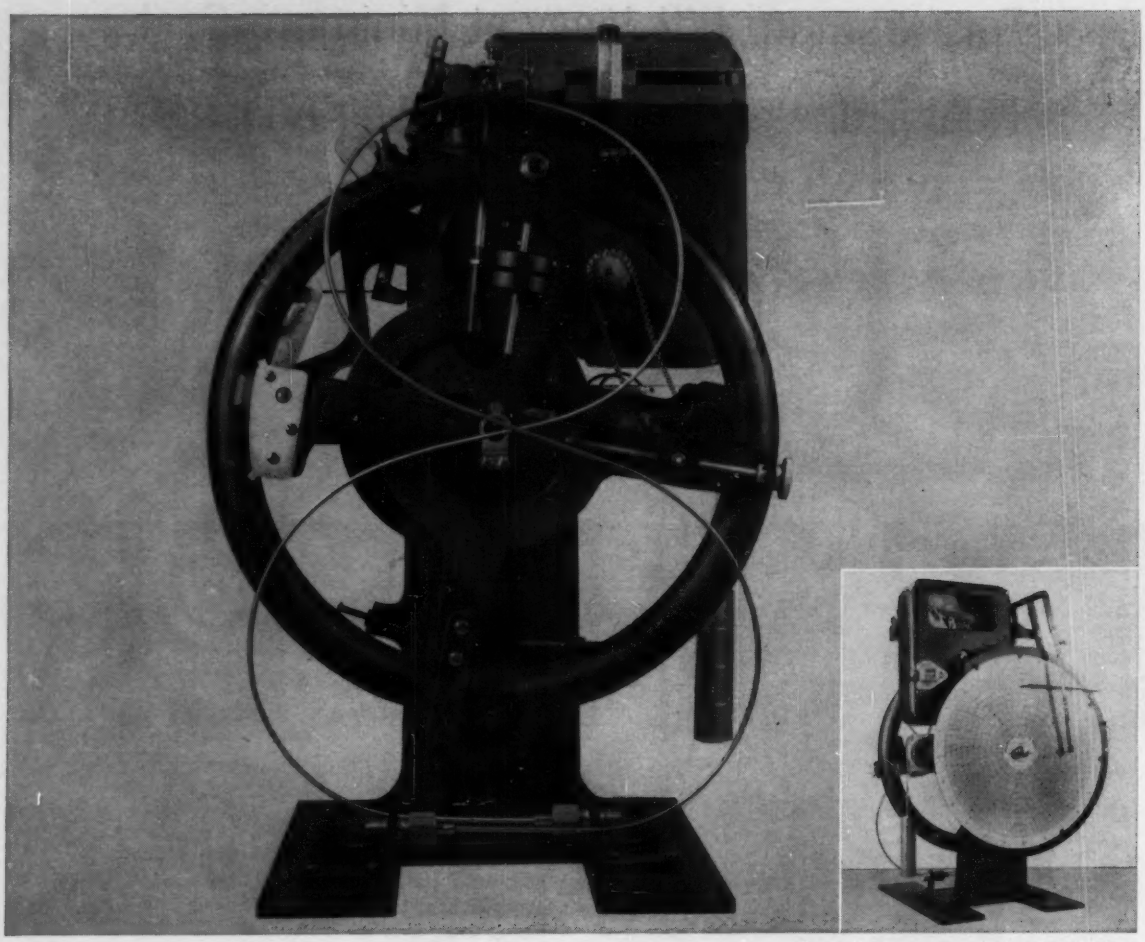
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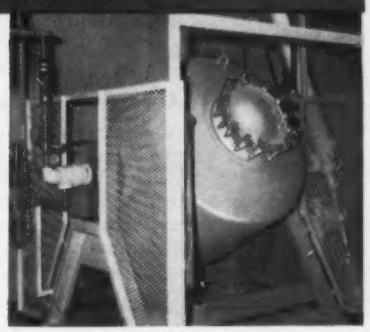
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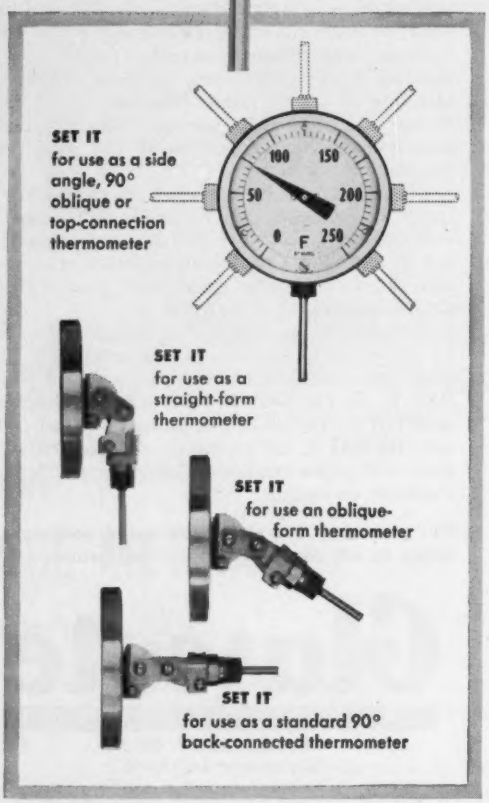


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Only this new American Thermometer* gives you the three features most demanded in a dial thermometer. The "Every Angle" design allows you to install this thermometer *anywhere* . . . then angle it in the direction that provides easiest reading. The anti-parallax Maxivision dial guarantees the surest, sharpest, easiest reading. Graduations are carried on a raised ring, set close to the cover glass, with an index-type, functional pointer set at the same level. The result – no perspective effect – parallax error practically eliminated. Finally, bi-metal actuation insures high sensitivity, economy, and surety of operation.

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SPECIFICATIONS

5-Inch Type 5-6060 American "Every Angle" Bi-Metal Dial Thermometer

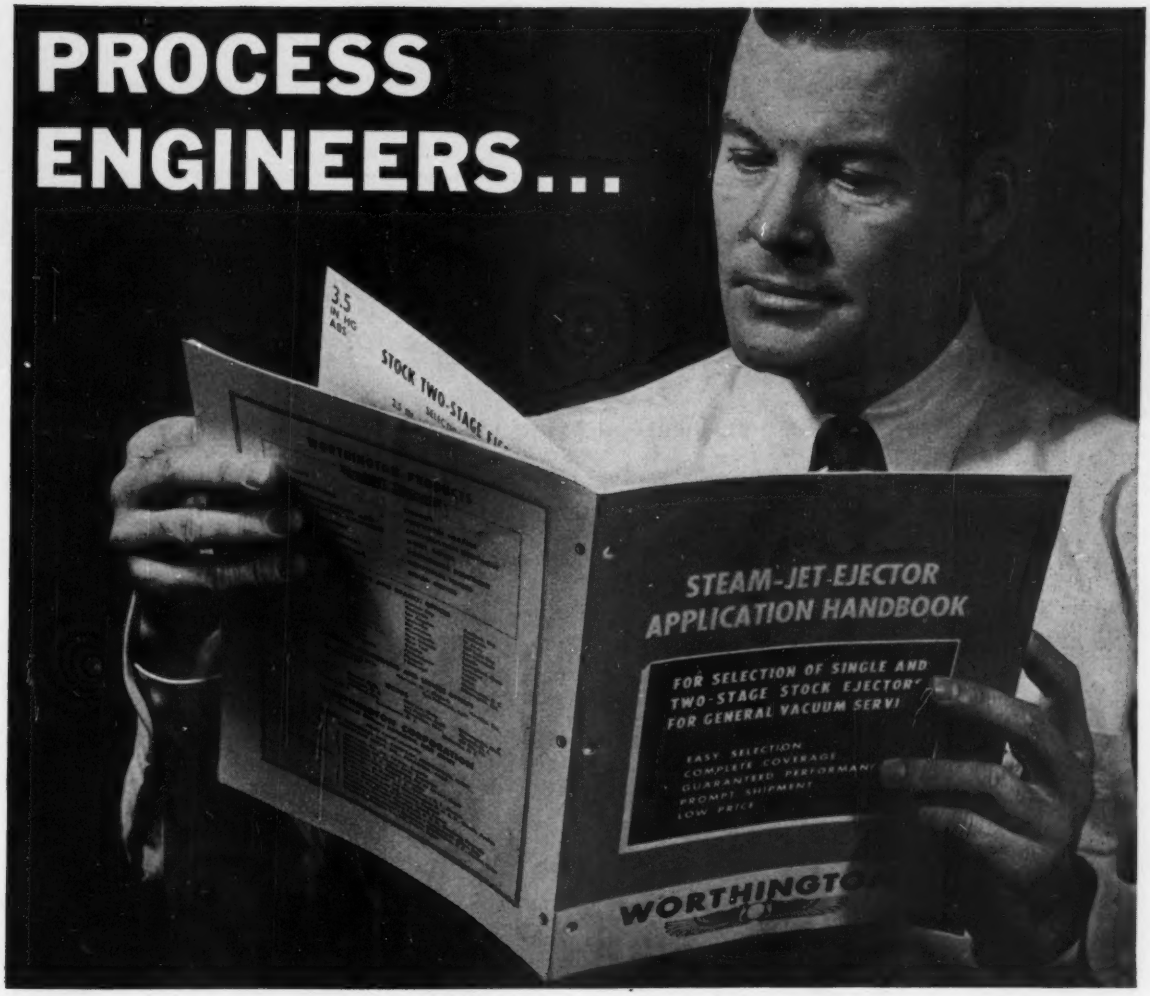
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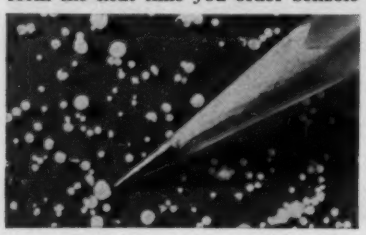
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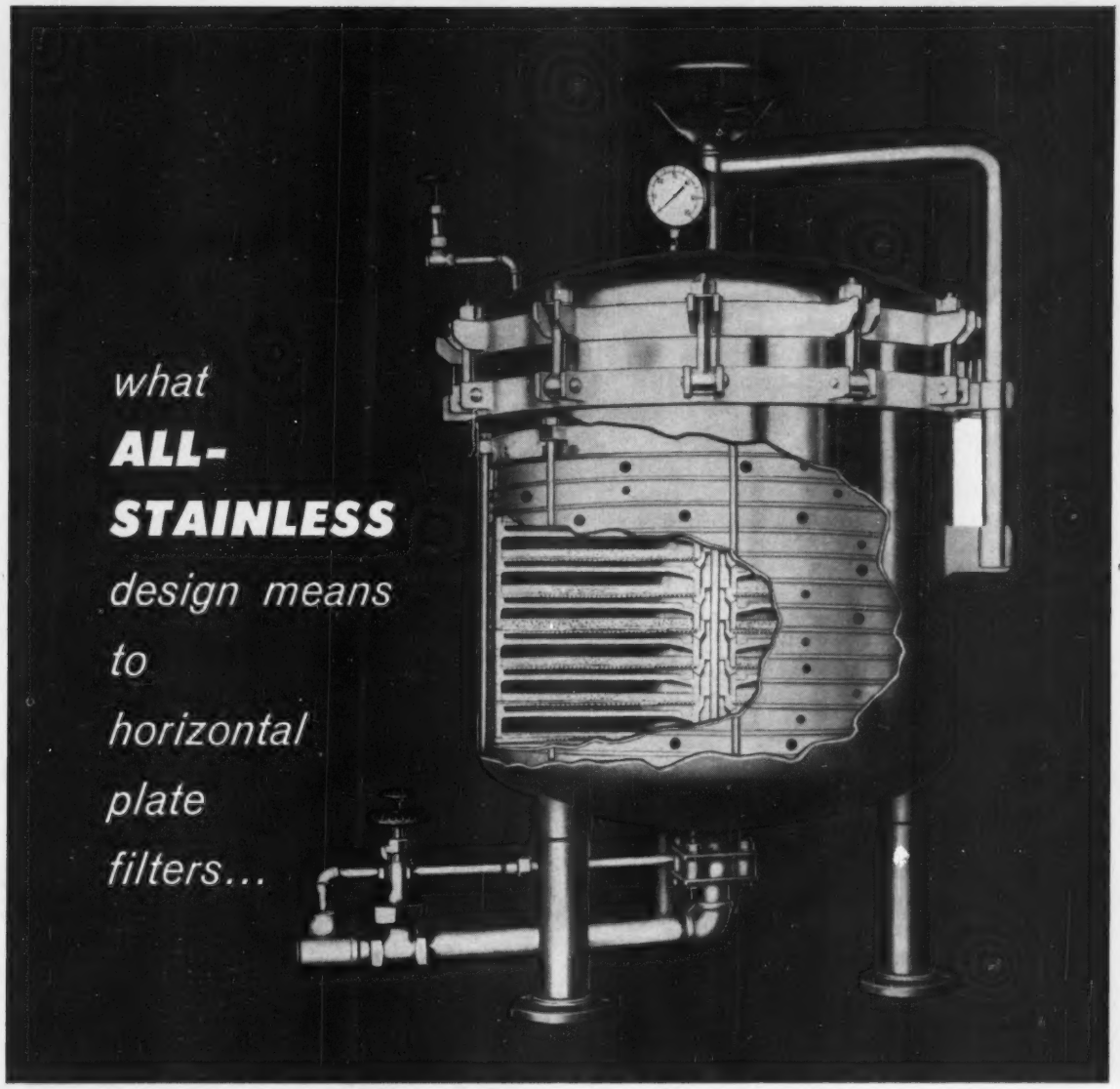
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The instrument engineer must be many men

There's no doubt that the instrument engineer is important during the planning and startup stages of an automatically controlled process. During this period he must be a good process design engineer . . . a good control engineer . . . a good supervisor. But . . . we sometimes overlook the fact that, after the new process has finally settled down to normal routine operation, the instrument engineer's job has really just begun. For now he must be a good —

Operating Engineer . . .

Because he has to carefully check the operation of each critical instrument—know how to "tighten" control through careful tuning. If there is need for a change in the type of control, or if an additional instrument must be added he must be able to make the right decisions.

Trouble Shooter . . .

Because instruments are sometimes blamed for the limitations or deficiencies of other equipment. He must be able to diagnose operating difficulties . . . isolate the cause. If the processing equipment is giving trouble he must report it quickly. If the control loop is at fault he must see that it's quickly corrected.

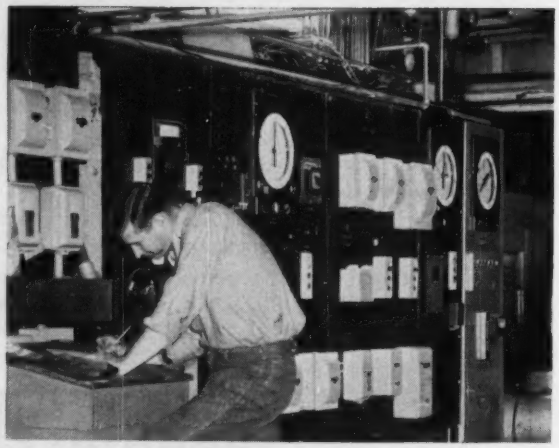
Manager . . .

Because he must keep complete records of instrument maintenance costs. These records will help him select instruments for new projects . . . enable him to decide when existing instruments should be replaced . . . help him in arriving at the correct inventory of spare parts and expendable items.

Know Your Instrument Engineer

He's a key man of automation. Whether you're at the design stage, the specifying stage, the installation stage, or the all-important operating stage, it will pay you to make his acquaintance. He knows instruments and controls. He knows your processes. And he knows how to combine the two to keep your processes "on stream" with maximum economy and minimum down time.

"Enamelstrip" ends air pollution, boosts output 400%



Control for Enamelstrip Corporation's ***Oxycat*** *system is centered on this panel. Included are* ***ElectroniK*** *controllers for temperatures and combustible gas percent, and* ***Protect-O-Vane*** *excess temperature safety cutoff for catalyst bed.*

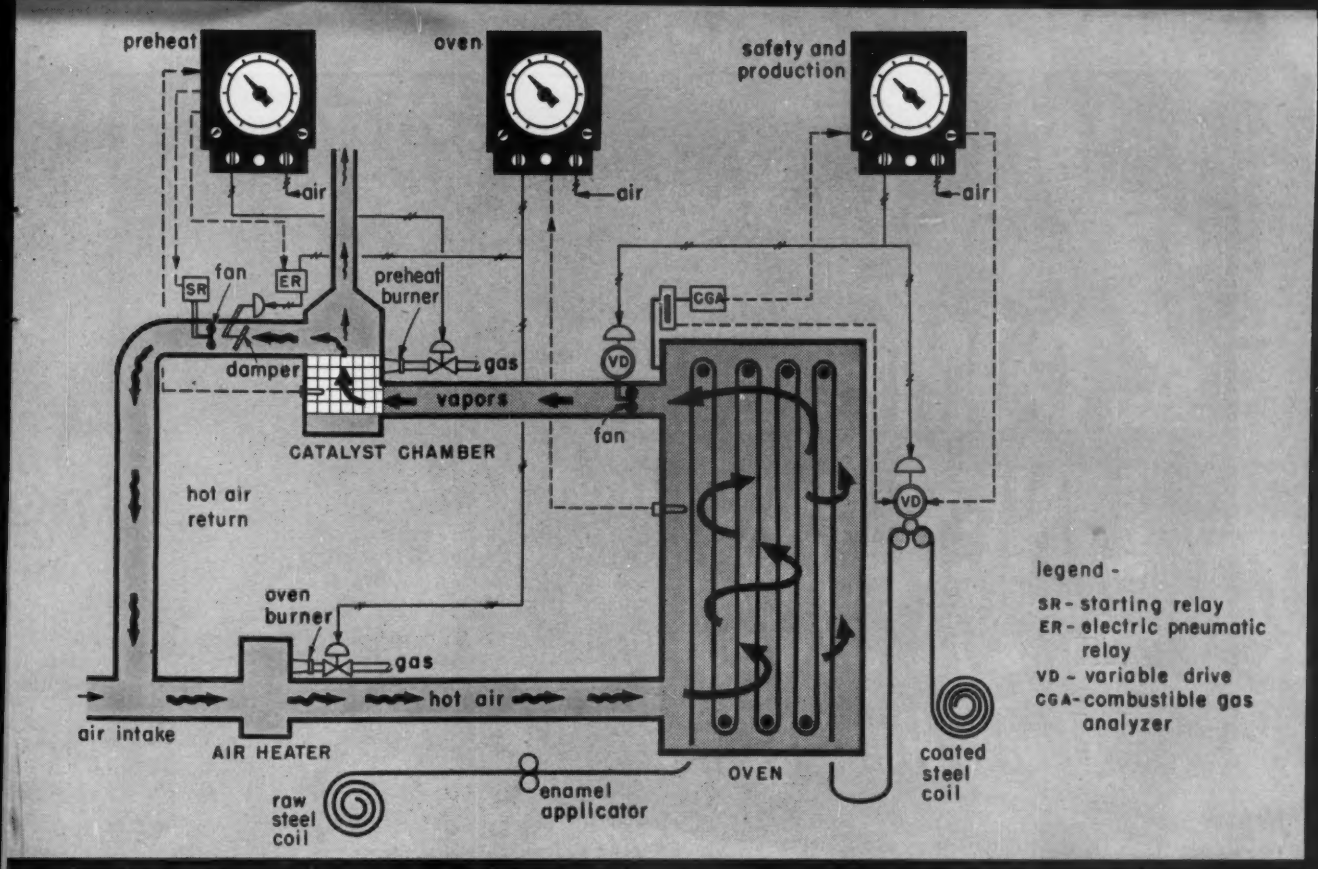


Diagram shows elements of coordinated control for enameling oven and exhaust gas catalytic burner.

. . . using Honeywell controls

PUTTING automatic control to work to solve one problem often pays dividends in unexpected ways. Take the experience of Enamelstrip Corporation, Allentown, Pa. Pungent solvent fumes from their enamel baking ovens created an air pollution problem. With Honeywell engineers, they developed an *ElectroniK*-controlled oxidation catalyst system that turns the pungent solvent fumes into clean, hot gas. The catalyst itself, *Oxycat*, was developed and installed by Oxy-Catalyst, Inc., of Wayne, Pa.

Results have exceeded expectations. Enamelstrip's oven exhaust is 99% pure, and the pollution threat is ended. But this is only part of the success of this installation. So much heat was being generated by the oxidation catalyst that Enamelstrip decided this heat was too valuable to waste. So a second control system, also using *ElectroniK* instrumentation, was designed to recirculate the clean hot gases back to the oven. Results? *Fuel costs for the oven are down 80%.*

And *production has soared 400%* because of a third *ElectroniK*-equipped control system. This instrument continuously records concentration of combustible gases in the oven and automatically adjusts production rates to keep output at its peak safe value.

Finally, Enamelstrip's coordinated control system does such a thorough job of balancing safety against production that the firm's insurance rates have tumbled from $1.25 to less than $0.06 per thousand, a *drop of more than 95%*.

Thus Enamelstrip has recaptured its original $30,000 anti-pollution investment on *each* of three counts: fuel savings, production increase, and insurance rebate.

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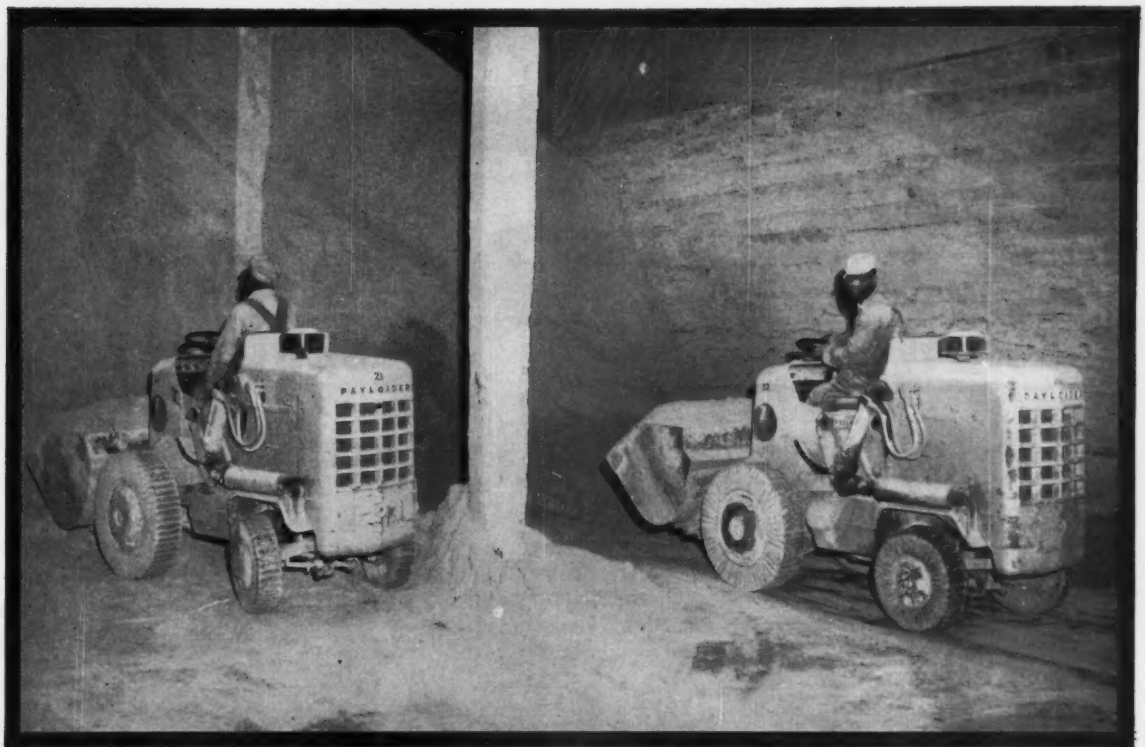
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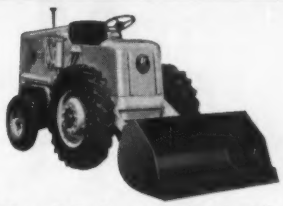
2 new-design PAYLOADER® shovels do the work of 4 previous units

The new-design model HA "PAYLOADER" has already proven that it is the production champion in its class. Long-time "PAYLOADER" users, as well as new owners, report new highs in production and new lows in bulk-material handling costs with the new HA. A typical report is from G. N. Williams, Supt. of Fertilizer Division of Planters Cotton Oil & Fertilizer Co. of Rocky Mount, N. C., who says,

"On manufacturing operations two new-design 'PAYLOADER' shovels are doing the job of 4 previous units. These new HA's load faster and easier, travel faster with better operator vision and increased operator safety. On manufacturing operation, these two HA's move about 400 tons under a good day's run on an average haul of 75 feet. We are still operating three older 'PAYLOADER' shovels purchased in 1946."

If you have any bulk materials to scoop-up, carry, load, dump, stockpile or spread, you should find out how the new-design model HA or a larger "PAYLOADER" model can help. There's a Hough Distributor ready to show you.

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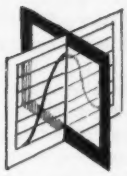
Vogt GENERAL GP PURPOSE Vogt FOR BETTER VALVES

DROP FORGED STEEL

VALVES

Chemical Engineering
MARCH 1956

Industrial Statistics



How to get more information from chemical engineering data—use statistical treatment. The dynamic procedures of this new and important tool are detailed for you in this CE Report.

WILLIAM VOLK, Hydrocarbon Research, Inc.

STATISTICS is becoming, more and more, a necessary tool for the chemical engineer as competition gets keener, and as the costs involved in design, development and production continue to rise. For this powerful tool, when used correctly, will extract for you the maximum amount of information from engineering data.

Until a decade or so ago the agriculturist, because of inherent variability of soil and weather; the physical chemist, because of the precisions of his measurements; the social scientist, in his never-to-be-successful search for the "average man"; and of course the professional gambler, for obvious reasons, had the field of statistical analysis pretty much to themselves. Relatively recently, increasing amounts of engineering data are being statistically analyzed, and means, standard deviations, and confidence ranges are becoming almost as popular as equilibrium data and vapor pressures.

The purpose of this report is to define the more readily useful statistical tools; to give examples of the use of statistics for getting more from data and to understand better the limitations of data. We do not intend to contribute anything new to the field of statistics, and will in fact avoid all mathematical derivations and theory. However, numerous examples will be given of basic statistical methods applied to engineering problems in such a way that the methods can be readily understood.

Two Concepts Are Basic in Statistics

Most engineers know that the average is a measure of uniformity of data. But many don't realize that the variability of data can tell them how reliable the average is.

There are two quantities most helpful in describing data and comparing two sets of data. One is the number around which most of the data cluster. And the other is some number which represents the spread, or dispersion of data.

Averages Are Important

The mean, $\bar{x}$, which is the arithmetic average—the most common representation of the central tendency of data—is the most useful for statistical purposes. There are other measures of the central tendency which have special uses and are mentioned below. You calculate a mean, $\bar{x}$, by dividing the sum of individual terms by the number of terms:

$$\bar{x} = \frac{\sum_{i=1}^{n} (x_i)}{n}$$

In addition to the simple mean, there is the harmonic mean and the geometric mean.

The harmonic mean, $\overline{H}$, is the reciprocal of the arithmetic mean of the reciprocals, and is used whenever reciprocals are involved, e.g., rates. For example, to get the average rate of flow for a stream delivering 100 gal. at 50 gpm., 100 at 60 gpm. and 100 at 70 gpm., it's necessary to use the harmonic mean.

$$\overline{H} = n/\left(\sum_{i=1}^{n} 1/x_i\right)$$

$$\text{Average Rate} = 3/\left(\frac{1}{50} + \frac{1}{60} + \frac{1}{70}\right)$$
$$= 58.8 \text{ gpm.}$$

The geometric mean, $\overline{G}$, is the n^{th} root of the product of n terms, and is used when averaging numbers involving growth data. For example, the crude oil production in the United States increased every year from 1938 to 1948. The 1938 production in 1,000 B/D was 3,290 and in 1948 was 5,520, with a geometric mean of 4,261 and an arithmetic mean of 4,405. Actual 1943 production of 4,125 is more nearly approximated by the geometric mean than by the arithmetic mean.

Other measures of the central tendency of a group of numbers are the median and the mode. The median, is the value occurring midway in the data (or the mean of the two central values for an even number of data) when the data are arranged in order of value. A median is not affected by extremely large or small values and is frequently used when there is a large discrepancy between the largest and smallest value.

The mode is the most frequently occurring value and applies when there is a large frequency of one value to be averaged with one or a few large numbers. For example, the mode of twenty 10,000 B/D and one 250,000 B/D refineries is 10,000 B/D which is certainly more typical than the mean of 21,000 B/D which represents none of the actual data.

In the statistical discussions which follow only the mean, or arithmetic average, will be used, since it is most sensitive to all of the data.

Measures of Dispersion

The spread of data may be represented in several ways, but the most useful way, although not the simplest, is by the standard deviation, σ, (sigma). This, sometimes known as the root mean square deviation, is defined as

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (\bar{x} - x_i)^2}{n}}$$

i.e., the square root of the mean of the squares of the deviations from the group mean. Squaring the standard deviation gives a term called the variance (σ^2). Units of the standard deviation are the same as for the individual measurements. Remember, however, that σ is the standard deviation of the *total* population of data. It can be shown that the standard deviation of means calculated for samples taken from this population will have a standard deviation equal to $\sigma/\sqrt{n}$, where n is the sample size. In other words,

WILLIAM VOLK is a Senior Research Engineer at the Trenton, N. J. Labs of Hydrocarbon Research, Inc. He took his undergraduate chemical engineering degree at N.Y.U. in 1939 and his graduate work at the Polytechnic Institute of Brooklyn. At present he also teaches a graduate course in the application of statistical techniques to chemical engineering data at Brooklyn Poly. Mr. Volk holds professional engineering licenses in New York, New Jersey and Illinois. He first became interested in statistical work during World War II while supervising a research group in the Manhattan Project with the Kellex Corp. Later, following a two year stint with the Emulsol Corp. in Chicago after the war, he joined the laboratory staff of Hydrocarbon Research, where he has specialized in statistical work.



the spread of these means is less than the spread of the over-all data around the group mean.

Another measure of the spread of the data is the average deviation. This is simply the arithmetic average of the deviation from the mean without regard to sign.

$$\text{Average Deviation} = \frac{\sum_{i=1}^{n} (\bar{x} - x_i)}{n}$$

For a normal distribution, the standard deviation is approximately 1.25 times the average deviation. It's possible therefore for an experienced operator or analyst who knows what the average deviation usually is to convert to the standard deviation by this relation and to make use of the statistical tools to be described.

The last measure of dispersion to be mentioned is the range (for details on use of range, see Ref. 2) which is the difference between the largest and the smallest value. For small quantities of data (less than 10) the range is a useful number for comparison and is used in sampling and quality control. However, since it is only affected by two of the data points, it obviously loses power as the size of the sample increases. It will not be used in any of the discussions covered here.

Although the standard deviation is the most complicated to calculate of the dispersion measures, it is by far the most powerful and it will repay in usefulness for its extra inconvenience.

Basis of Statistical Analysis

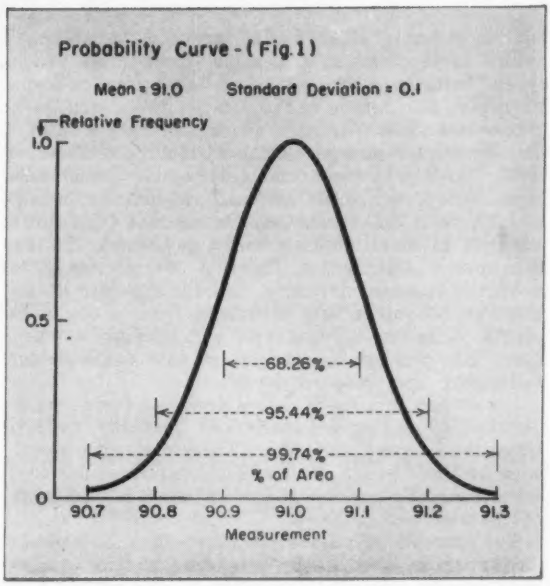
Statistical formulas are based on mathematical distribution functions. There are several of these functions which will be mentioned.

We all know that you can't make the identical chemical on a production scale from batch to batch, or from day to day. There will be come variability due to the process, and also due to errors in measuring properties.

If a large number of small errors are all operating independently any data collected from the process will be distributed along some distribution or frequency curve.

The most important of these curves is the "normal" distribution, developed about 1730 by mathematicians working on the theory of games. Usefulness of the normal curve (which is the basis for all the statistical methods to follow) lies in the fact that from two numbers: the mean $\bar{x}$, and the standard deviation σ, the distribution of all of the data can be established. The following table gives the fractions of the total distribution that lie within various ranges around the mean, and Fig. 1 shows a normal curve with a mean of 91.0 and a standard deviation of 0.1.

% of Total Data	In the Range $\bar{x} \pm$
50	0.6745σ
68.2	1.00σ
75	1.15σ
90	1.65σ
95	1.96σ
95.45	2.00σ
99	2.57σ
99.73	3.00σ



In other words, 95% of the distribution forming Fig. 1 lies in the range of 91.0 ± (1.96) (0.1) or from 90.804 to 91.196. This information can be very useful. If a process gave results that were known to fit a normal distribution having a mean of 91.0 and a standard deviation of 0.1 it would be known that there was only a 5% chance of a result falling outside the range of 90.804 to 91.196. If you then get a result of 91.2 you could report with a 95% chance of being correct that the process was not acting in its usual manner.

Why Be 95% Sure?

It's customary to work at the 95% or 99% probability levels, corresponding approximately to the two sigma (2σ) and three sigma levels. The reason for choosing these levels can be illustrated by an analogy.

If any organization decides to base its hiring of new engineering applicants on an examination, and to hire those who pass and not to hire those who fail, two types of errors can be made. A well qualified applicant may fail because of nervousness or other extraneous causes. This is the statistical Type I error—false rejection. Or a non-qualified applicant may pass by guessing or by cheating. This is the statistical Type II error—false acceptance. If the tests is made very difficult so as to eliminate all chance of the non-qualified applicant passing, then more of the good men will be turned away. On the other hand, if the test is made easy so that there is very little chance of the qualified man failing, then more of the non-qualified will pass. In the first case, by eliminating the Type II error, the chance of Type I error is increased. In the second case the reverse situation holds.

The 95% probability level, which gives a 5% chance of a Type I error, represents the usual optimum for the minimum number of total errors. At the 99% level, there is only a 1% chance of a Type I error,

but more chance of a Type II error. At what probability level decisions are made depends on which type of error is more important. Usual practice keeps the errors about equal at the 95%, or two sigma level.

It would require a large amount of data to establish firmly, for any particular case, that a distribution of such data was normal. However, if a process is subject to a number of small random fluctuating factors, then experience has shown that in a large majority of cases the distribution is normal. To use the normal distribution function it's necessary to know the standard deviation, and the standard deviation can be only poorly estimated from a few data points. The *t*-test (which we will take up shortly) takes into account the amount of data available for estimating the standard deviation.

Remember, that the standard deviation for a normal distribution is approximatey 1.25 [actually $(\pi/2)^{\frac{1}{2}}$] times the average deviation. Therefore, with knowledge of the average deviation derived from previous experience, it's possible to get a reasonable estimate of the standard deviation.

For example, if an analyst knows that the average deviation for a certain process is 0.5 and in a series of duplicates gets the following results: 26.4, 27.2, 26.8, 28.0 (for another way of doing this, see Ref. 2) he might be inclined to discard the last result as being beyond the average deviation from the other three.

Let's apply some statistics. The average of the first three results is 26.8, and if the average deviation is 0.5, the standard deviation is (1.25) (0.5) = 0.625. From the table for the normal distribution, we may expect 95% of the results to fall within 26.8 ± (1.96) (0.625) or from 25.6 to 28.0. Therefore, unless the analyst is willing to be less than 95% certain, the 28.0 value should not be discarded.

In handling a situation of this kind, it's important that the average deviation be established before such data are analyzed. Once the data are available they're bound to affect any estimate of the average deviation —especially to an operator who knows that he is planning on discarding numbers lying 3.0 or 3.5 average deviations from the mean.

Non-Normal Distributions

There is one more use of the $\bar{x}$ and sigma combination that we'll mention before getting to the *t*-test. It's known that regardless of the type of distribution of the data a minimum of $1\text{-}1/Z^2$ of the total data lie in the range $\bar{x} \pm Z\sigma$ (when Z is not less than 1). For example, if $Z = 1.96$, $\bar{x} \pm 1.96\sigma$ contains at least 74% of the data:

$$1 - \frac{1}{(1.96)^2} = 1 - 0.26 = 0.74$$

We can apply this test to the four analyses in the

Probability of a Larger t Value—Table I

D.f.	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.001
1	1.00	1.38	1.96	3.08	6.31	12.71	31.82	63.66	636.62
2	0.82	1.06	1.39	1.89	2.92	4.30	6.97	9.92	31.60
3	0.76	0.98	1.25	1.64	2.35	3.18	4.54	5.84	12.94
4	0.74	0.94	1.19	1.53	2.13	2.78	3.45	4.60	8.61
5	0.73	0.92	1.16	1.48	2.02	2.57	3.36	4.03	6.86
6	0.72	0.91	1.13	1.44	1.94	2.45	3.14	3.71	5.96
7	0.71	0.90	1.12	1.42	1.90	2.36	3.00	3.50	5.40
8	0.71	0.89	1.11	1.40	1.86	2.31	2.90	3.36	5.04
9	0.70	0.88	1.10	1.38	1.83	2.26	2.82	3.25	4.78
10	0.70	0.88	1.09	1.37	1.81	2.23	2.76	3.17	4.59
11	0.70	0.88	1.09	1.36	1.80	2.20	2.72	3.11	4.44
12	0.70	0.87	1.08	1.36	1.78	2.18	2.68	3.06	4.32
13	0.69	0.87	1.08	1.35	1.77	2.16	2.65	3.01	4.22
14	0.69	0.87	1.08	1.34	1.76	2.14	2.62	2.98	4.14
15	0.69	0.87	1.07	1.34	1.75	2.13	2.60	2.95	4.07
16	0.69	0.86	1.07	1.34	1.75	2.12	2.58	2.92	4.02
17	0.69	0.86	1.07	1.33	1.74	2.11	2.57	2.90	3.96
18	0.69	0.86	1.07	1.33	1.73	2.10	2.55	2.88	3.92
19	0.69	0.86	1.07	1.33	1.73	2.09	2.54	2.86	3.88
20	0.69	0.86	1.06	1.32	1.72	2.09	2.53	2.84	3.85
21	0.69	0.86	1.06	1.32	1.72	2.08	2.52	2.83	3.82
22	0.69	0.86	1.06	1.32	1.72	2.07	2.51	2.82	3.79
23	0.68	0.86	1.06	1.32	1.71	2.07	2.50	2.81	3.77
24	0.68	0.86	1.06	1.32	1.71	2.06	2.49	2.80	3.74
25	0.68	0.86	1.06	1.32	1.71	2.06	2.48	2.79	3.72
30	0.68	0.85	1.06	1.31	1.70	2.04	2.46	2.75	3.65
40	0.68	0.85	1.05	1.30	1.68	2.02	2.42	2.70	3.55
60	0.68	0.85	1.05	1.30	1.67	2.00	2.39	2.66	3.46
120	0.68	0.84	1.04	1.29	1.66	1.98	2.36	2.62	3.37
∞	0.67	0.84	1.04	1.28	1.64	1.96	2.33	2.58	3.29

Note: Table I was abridged from "Statistical Methods for Research Workers" by Fisher, published by Oliver and Boyd, Ltd., Edinburgh.

t Equations—Table II

Hypothesis: $\bar{x} = m$

$$t = (\bar{x} - m)/s(\bar{x})$$

d.f. $= n - 1$

Hypothesis: $\bar{x} = 0$

$$t = (\bar{x} - 0)/s(\bar{x})$$

d.f. $= n - 1$

Hypothesis: $\bar{x}_1 - \bar{x}_2$

$$t = (\bar{x}_1 - \bar{x}_2)/s(\bar{x})$$

d.f. $= n_1 + n_2 - 2$

Test

For probability, insert calculated *t* into body of Table I at proper d.f. (degrees of freedom) to find probability level. This level will indicate the probability of getting as large a *t* value by chance if the hypothesis is true. Or another way of saying it: it's the probability level of making an error by rejecting the hypothesis.

previous example. The mean and standard deviation of the first three analyses are 26.8 and 0.326. It is important to note that the standard deviation of 0.326 calculated for the numbers 26.4, 27.2, and 26.8 is *not* a standard deviation of a normal distribution, nor is it an estimate of one. It's only the standard deviation of the three numbers involved, and has no other significance. From the $\bar{x}$ value of 26.8 and the value of 0.326, we can compute the fraction of numbers from this distribution regardless of its form, that would include the value 28.0, i.e., 26.8 ± 1.2. Therefore $Z\sigma$ equals 1.2 and Z equals 3.68. Then

$$1 - \frac{1}{(3.68)^2} = 0.926.$$

We're saying that 92.6% of numbers distributed like the first three lie in the range 25.6 to 28.0 regardless of the form of the distribution, and to discard the 28.0 analysis would mean acting with less than 92.6% certainty. This relation, known as Tchebycheff's inequality, gives the minimum data included in any range.

How to Compare Two Results

Are those two results really different? Either the powerful t-test (for measurement data) or the chi-squared test (for enumeration data) will give you an answer.

One of the most frequent problems that comes up in engineering work is this: Is the difference between two sets of data real and significant, or just due to chance errors?

There are two important statistical tests which will answer this important question for you. One is the *t*-test, and the other is the chi-squared test. There is an important distinction to be made between the two. The *t*-test applies to continuous data—usually a measurement (temperature in a reactor, yield per batch) that gives a smooth and continuous distribution curve. The chi-squared test is designed for frequency or count type of data. Information is in the form of distinct integers (number of accidents per shift, number of defectives per cycle, successful batches per day). This data would not produce a continuous distribution curve.

The *t*-Test

The statistic t (so named by its originator W. S. Grosset in 1908) compares the observed difference between averages with the inherent variability within the data (as measured by the standard deviation) to tell whether the difference is significant.

Success of this test depends on a very important law of nature. For any distribution, if you take groups of samples from a distribution, you'll find that the means of the groups will tend to distribute themselves around a normal distribution—even when the original distribution was not normal. Of course, the larger the number of samples, the closer will the distribution of means approach the normal. The *t*-test makes use of this very useful law in comparing means.

Just to pinpoint the relationship: an ordinary deck of cards has a rectangular distribution—frequency of each value is the same. However, the distribution of means of a number of five cards hands will approach a normal distribution.

In the *t*-test:

$$t = \frac{\bar{x} - m}{s(\bar{x})}$$

where x is the measured mean, m is the true mean and $s(\bar{x})$ is the estimated standard deviation of the mean.

Before we give some examples of the use of this test there are two terms to be defined; the estimated standard deviation and degrees of freedom. The estimated standard deviation is a number calculated from a random sample in an attempt to estimate the standard deviation of the population from which the sample is drawn. The standard deviation of the sample must be calculated around the sample mean, $\bar{x}$ i.e., $[\Sigma\ (\bar{x} - x)^2/n]^{0.5}$. But since the true mean is not necessarily $\bar{x}$, the standard deviation calculated from $\bar{x}$ is based low. It has been shown that the best correction for this bias is to divide the sum of squares of deviations by $(n\text{-}1)$ instead of n. Therefore, the estimated standard deviation, designated s to distinguish it from the true standard deviation σ, is computed as follows:

$$s(x) = \sqrt{\frac{\Sigma(\bar{x} - x)^2}{n - 1}}$$

An estimated standard deviation of the mean has the same relation to the estimated standard deviation of the population as the true standard deviation of the mean:

$$s(\bar{x}) = s(x)/n^{0.5}$$

As n, the sample size, gets larger, the effect of the minus one correction becomes less, and is usually omitted at n greater than 200.

Degrees of freedom have a similar meaning to the

Fundamental Nomenclature

m	True mean
σ	Standard deviation of infinite amount of data
σ^2	Variance of infinite amount of data
s^2	Estimated variance from finite data
s	Estimated standard deviation from finite data
$s(\bar{x})$	Estimated standard deviation of the mean
$\overline{s(\bar{x})}$	Pooled estimated standard deviation of the mean
$\bar{x}$	Sample mean
n	Sample size
$\Sigma'x^2$	Sum of squares=$\Sigma(x-\bar{x})^2$
α	Significance level (probability of Type I error)
Z	Standard coefficient for normal distribution

What's in It for You?

One thing is certain. Industrial statistics is no longer a static method for reducing a large mass of data to a few summary figures. It has developed into a new science involving dynamic procedures for the collection, analysis and interpretation of data. Particular attention has been given, in this development, to situations where only a small amount of data is available.

same term in physical chemistry—the number of independent categories that can be varied. In this case, in the calculation of the standard deviation, the number of the sample n is fixed and the standard deviation is calculated from the mean. Only n-1 of the sample terms can be varied and the last term is fixed by $\bar{x}$ and n. Therefore, there are n-1 degrees of freedom in estimating the standard deviation from a sample.

How to Use Table

Table I gives the values for t for various degrees of freedom. The probability level is the chance of getting a value larger than the table values by chance alone.

From the table, at 20 degrees of freedom, a t value as large as 2.09 would occur 1 in 20 times (probability level is 0.05) by chance.

A t value as large as 2.84 would only come up 1 in 100 times (probability level of 0.01) by chance. So if your test comes up with a t of 2.84 you're safe in saying that other factors, besides chance factors, are acting on the system, for it would be highly unlikely to get 2.84 just from the normal errors acting on the data.

You should note from the table, that t values approach the probability values for the normal curve as the sample size (degrees of freedom) increases. Beyond a d.f. of 120, there is no difference between t and the normal curve values.

The t-test consists of setting an hypotheses for the value of the mean (usually you first assume there is no difference between the means) then calculate t from the observed mean and estimated standard deviation, and then compare the calculated t with the tabulated values of t. If the calculated t exceeds the tabulated value at the proper degrees of freedom, then the original hypothesis may be rejected with the chance of being wrong corresponding to the probability level. Table II shows the common hypotheses and t equations.

Let's Work Some Examples

The following examples illustrate the use of the t-test.

Example 1: $\bar{x} = m$

Five analyses have been run on a gas sample, with the following results for a C_4 cut: 12.4, 12.6, 12.3, 12.7, 12.5%. Is the average significantly different from an assumed mean value of 12.6%?

Mean, $\bar{x}$, is 12.5%.

Estimate of the standard deviation of the mean, $s(\bar{x})$ is 0.071.

Degrees of freedom, d.f., are 4.

Hypothesis: $\bar{x} = 12.6$

$$t = (12.6 - 12.5)/0.071 = 1.41$$

The value corresponds in the t table, at a d.f. of 4, to a probability level between 0.30 and 0.20. This means that if we say the average C_4 cut is significantly different from 12.6% we will be wrong about 25% of the time with data like this. Or, another way of saying it is that a value as large as 1.41 will occur about 25% of the time, if there is no significant difference between 12.6 and 12.5.

Example 2: $\bar{x} = 0$

If you want to know whether there's a difference in measurements by comparing two sets of means, it's useful to try and pair the measurements if they are made under similar conditions or have something in common—on the same day, or the same batch, or by the same person. Then the average difference between the measurements is tested. Here $\bar{x}$ is the difference between duplicates and we want to test whether $\bar{x}$ is different from zero.

Two shifts give the following carbon determination on different samples run over a period of a week. Is there a difference between shifts?

Day	Shift A	Shift B	Difference
1	15.2	14.8	−0.4
2	14.7	14.0	−0.7
3	15.1	14.6	−0.5
4	14.7	14.2	−0.5
5	15.3	15.3	−0.0
6	15.1	14.8	−0.3
7	14.9	14.5	−0.4

$\bar{x} = -0.4$

$s(\bar{x}) = 0.0815$

d.f. = 6

Hypothesis: $\bar{x} = 0$

$$t = [0 - (-0.4)]/0.0815 = 4.91$$

This corresponds in the t table to a probability level between 0.01 and 0.001 so that there is less than one chance in a hundred that we will be wrong if we reject the hypothesis that there is no difference between shifts. Another way of saying it: A value as large as 4.91 will occur only once in a hundred.

Example 3: $\bar{x}_1 = \bar{x}_2$

In the formula in Table II for the t equation for this type of test, we show the estimated standard deviation of the mean as $\bar{s}(\bar{x})$ instead of simple $s(\bar{x})$. Actually $\bar{s}(\bar{x})$ is a pooled estimate of the standard deviation of the mean obtained from the two sets of data which give $\bar{x}_1$ and $\bar{x}_2$. Since these two sets of data give independent estimates of the standard deviation, they may be pooled for an over-all better estimate. (There may be cases when the two deviations are too different to be pooled. A test for this will be discused later.) A quick rule for samples of 5 to 10 items is not to pool the standard deviations if the ratio of the individual values is greater than 2.2. Formulas for calculating $\bar{s}(\bar{x})$ are given below together with the similar formulas for $s(\bar{x})$ to show the relation between the pooled estimate and the individual estimates of the standard deviation.

$$s(x) = \sqrt{\frac{\Sigma(\bar{x} - x)^2}{n - 1}}$$

$$\bar{s}(x) = \sqrt{\frac{\Sigma(\bar{x}_1 - x_1)^2 + \Sigma(\bar{x}_2 - x_2)^2}{n_1 + n_2 - 2}}$$

$$s(\bar{x}) = s(x)/\sqrt{n}$$

$$\bar{s}(\bar{x}) = \bar{s}(x)\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$\text{d.f.} = n - 1$$

$$\text{d.f.} = n_1 + n_2 - 2$$

If, for example, material was received from two sources of supply and separte analyses on samples from the two shipments gave the results listed below, would there be justification for saying there was a difference between the two materials?

	Shipment 1		Shipment 2
	75.0		79.0
	77.0		77.5
	84.0		74.0
	84.5		71.5
	74.5		79.0
	74.0		
	85.0		
$\bar{x}$ =	79.1		76.2
n =	7		5
$s(\bar{x})$ =	1.93		1.48
$\bar{s}(\bar{x})$ =		2.61	
d.f. =		10	
Hypotheses:	$\bar{x}_1$	=	$\bar{x}_2$

$$t = (79.1 - 76.2)/2.61 = 1.11$$

At 10 degrees of freedom, this t value represents a probability of about 0.25 and we cannot with reasonable certainty reject the hypothesis that $\bar{x}_1 = \bar{x}_2$.

Although the mean values of the two shipments seem to be different, the scatter in the individual samples casts too much doubt on the location of the true means. Let's see what happens if the means are unchanged but the scatter of the data is greatly reduced by the following example:

	Shipment 1		Shipment 2
	80.0		76.0
	76.0		77.5
	80.0		77.0
	80.5		75.5
	78.5		75.0
	79.0		
	80.0		
$\bar{x}$ =	79.1		76.2
n =	7		5
$s(\bar{x})$ =	0.583		0.463
$\bar{s}(\bar{x})$ =		0.800	
d.f. =		10	
Hypothesis:	$\bar{x}_1$	=	$\bar{x}_2$

$$t = (79.1 - 76.2)/0.800 = 3.62$$

Now if we reject the hypothesis that the means of the two shipments are the same we have less than one chance in a hundred of being wrong.

Both sets of comparisons had the same two means. In one case it would be reasonable to reject the hypothesis that the means were the same and in the other it would not. The reason for this difference in judgments is the different standard deviations or scatter of the data. This example has been given in this extra detail to emphasize how both the means and the standard deviations enter into statistical judgments made about data.

The t concept can also be used to establish a confidence range for the true mean. In this case the rearranged t equation is used:

$$m = \bar{x} \pm t\,s(\bar{x})$$

i.e., the true mean lies within some range of the observed mean, the range being set by the degrees of freedom used in getting $s(\bar{x})$ and the probability level of t. In the first example, with 4 degrees of freedom, we had an average C_4 analysis of 12.5% and an $s(\bar{x})$ value of 0.071. We may therefore set confidence limits on the true mean as follows:

Probability	Confidence Range
80%	$12.5 \pm (1.48)(0.071) = 12.4$ to 12.6
95%	$12.5 \pm (2.78)(0.071) = 12.3$ to 12.7
99%	$12.5 \pm (4.60)(0.071) = 12.2$ to 12.8

Computations

The formula for the standard deviation may be written in any of the following equivalent forms:

$$\sigma = \sqrt{\frac{\Sigma(\bar{x} - x)^2}{n}}$$

$$= \sqrt{\frac{\Sigma x^2}{n} - \frac{(\Sigma x)^2/n}{n}}$$

$$= \sqrt{\frac{\Sigma x^2 - \bar{x}\Sigma x}{n}}$$

If the computation is performed with an electric calculating machine, you can get $\Sigma\, x$ and $\Sigma\, x^2$ in one operation. Then, since $\bar{x}$ is necessary for most evaluations, statistical or not, the numerator of the last formula under the square root sign may be obtained in a second operation.

The same remarks apply to the calculation of the estimated standard deviation, s, with the exception that (n-1) instead of (n) appears in the denominator under the square root sign in each case.

If a calculating machine is not employed, it's useful to know that the standard deviation of a series of numbers which are added to a constant is the same with or without the addition. That is, if

$$x = y + a$$
$$\sigma(x) = \sigma(y)$$
$$s(x) = s(y)$$
$$s(\bar{x}) = s(y)$$

For instance, in Example 1, the estimated standard deviation of the mean of 12.4, 12.6, 12.3, 12.7, and 12.5 was calculated to be 0.071. This is the same as the estimated standard deviation of the mean of 0.4, 0.6, 0.3, 0.7, and 0.5; since 12.4 = 12.0 + 0.4, 12.6 = 12.0 + 0.6, etc. Thus, in calculation of standard deviations the data can be "coded" by adding or subtracting a constant number, greatly simplifying the calculations.

Enumeration Data

The t test deals with measurement or evaluation data which can fall anywhere between integers. A modification of the normal distribution was applied to establish confidence or expectancy ranges for locating the true measurements. Chi-squared (symbolized X^2) is a distribution applied to enumeration data (distinct integers like 1, 3, 5, 8 which would not produce a continuous distribution curve). It gives a test for determining whether the observed count differs significantly from an expected count.

If, for example, an election is expected to go 60-40 for your side, and a sample poll of 100 voters gives a result 52-48, do you have cause to revise your judgment of the ultimate result? A chi-squared test gives us a criterion for evaluating data of this nature.

Fundamentally, if you have a distribution of known frequency and draw samples from it, you will not get the identical frequency in the samples as exists in the parent distribution. As the samples get larger, the frequency distribution will approach more closely the frequency distribution of the total population. Chi-squared is a mathematical function which gives the probability of getting differences between the two frequencies, for varying sample sizes, when expressed in the following form:

$$X^2 = \sum \frac{(f - F)^2}{F}$$

where f is the observed frequency and F is the expected frequency.

Table III gives the chi-squared values for various probability levels and degrees of freedom (which term will be explained). It lists low and high probability values (90% of X^2 lies in the range 0.95 to 0.05).

How to Use Test

The procedure in using the chi-squared test is similar to that discussed for the t test. An hypothesis is set up on the observed frequencies: namely that they are equal to the expected frequencies, i.e., $f = F$. Chi-squared is calculated from the formula, and the result is compared at the proper level of degrees of freedom with the tabulated values. Any value of chi-squared in the table is the maximum value which could occur by chance alone, at a particular probability level. The degrees of freedom have the same meaning as described for the t-test; they represent the number of independent categories of frequencies.

In the first example, the expected frequencies are 60 and 40 in a sample of a 100 and the observed frequencies are 52 and 48. With 100 items in the sample, only one of the observed frequencies can be independently fixed, hence there is one degree of freedom. Chi-squared, is then calculated as follows

$$X^2 = \frac{(52 - 60)^2}{60} + \frac{(48 - 40)^2}{40} = \frac{64}{60} + \frac{64}{40} = 2.67$$

This value at d.f. = 1 corresponds to a probability level between 0.10 and 0.20 so that if the original hypothesis is rejected, there is between one and two chances in ten that an error will be made.

Suppose the sample poll was 1,000 instead of 100 and the percent distribution of returns was the same, i.e., 520:480. Then X^2 is 26.67, with 1 degree of freedom and a probability of less than 0.01 that you would get such a value by chance alone.

The Case for More Samples

With a sample of 100 we would not have rejected the 60/40 hypothesis, but with a sample of 1,000, and

Probability of a Larger Value of Chi-square—Table III

D.f.	0.99	0.98	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.02	0.01
1	0.000	0.001	0.004	0.016	0.064	0.148	0.455	1.074	1.642	2.706	3.841	5.412	6.635
2	0.020	0.040	0.103	0.211	0.446	0.713	1.386	2.408	3.219	4.605	5.991	7.824	9.210
3	0.115	0.185	0.352	0.584	1.005	1.424	2.366	3.665	4.642	6.251	7.815	9.837	11.341
4	0.297	0.429	0.711	1.064	1.649	2.195	3.357	4.878	5.989	7.779	9.488	11.668	13.277
5	0.554	0.752	1.145	1.610	2.343	3.000	4.351	6.064	7.289	9.236	11.070	13.388	15.086
6	0.872	1.134	1.635	2.204	3.070	3.828	5.348	7.231	8.558	10.645	12.592	15.033	16.812
7	1.239	1.564	2.167	2.833	3.822	4.671	6.346	8.383	9.803	12.017	14.067	16.622	18.475
8	1.646	2.032	2.733	3.490	4.594	5.527	7.344	9.524	11.030	13.362	15.507	18.168	20.090
9	2.088	2.532	3.325	4.168	5.380	6.393	8.343	10.656	12.242	14.684	16.919	19.679	21.666
10	2.558	3.059	3.940	4.865	6.179	7.267	9.342	11.781	13.442	15.987	18.307	21.161	23.209
11	3.053	3.609	4.575	5.578	6.989	8.148	10.341	12.899	14.631	17.275	19.675	22.618	24.725
12	3.571	4.178	5.226	6.304	7.807	9.034	11.340	14.011	15.812	18.549	21.026	24.054	26.217
13	4.107	4.765	5.892	7.042	8.634	9.926	12.340	15.119	16.985	19.812	22.362	25.472	27.688
14	4.660	5.368	6.571	7.790	9.467	10.821	13.339	16.222	18.151	21.064	23.685	26.873	29.141
15	5.229	5.985	7.261	8.547	10.307	11.721	14.339	17.322	19.311	22.307	24.996	28.259	30.578
16	5.812	6.614	7.962	9.312	11.152	12.624	15.338	18.418	20.465	23.542	26.296	29.633	32.000
17	6.408	7.255	8.672	10.085	12.002	13.531	16.338	19.511	21.615	24.769	27.587	30.995	33.409
18	7.015	7.906	9.390	10.865	12.857	14.440	17.338	20.601	22.760	25.989	28.869	32.346	34.805
19	7.633	8.567	10.117	11.651	13.716	15.352	18.338	21.689	23.900	27.204	30.144	33.687	36.191
20	8.260	9.237	10.851	12.443	14.578	16.266	19.337	22.775	25.038	28.412	31.410	35.020	37.566
21	8.897	9.915	11.591	13.240	15.445	17.182	20.337	23.858	26.171	29.615	32.671	36.343	38.932
22	9.542	10.600	12.338	14.041	16.314	18.101	21.337	24.939	27.301	30.813	33.924	37.659	40.289
23	10.196	11.293	13.091	14.848	17.187	19.021	22.337	26.018	28.429	32.007	35.172	38.968	41.638
24	10.856	11.992	13.848	15.659	18.062	19.943	23.337	27.096	29.553	33.196	36.415	40.270	42.980
25	11.524	12.697	14.611	16.473	18.940	20.867	24.337	28.172	30.675	34.382	37.652	41.566	44.314
26	12.198	13.409	15.379	17.292	19.820	21.792	25.336	29.246	31.795	35.563	38.885	42.856	45.642
27	12.879	14.125	16.151	18.114	20.703	22.719	26.336	30.319	32.912	36.741	40.113	44.140	46.963
28	13.565	14.847	16.928	18.939	21.588	23.647	27.336	31.391	34.027	37.916	41.337	45.419	48.278
29	14.256	15.574	17.708	19.768	22.475	24.577	28.336	32.461	35.139	39.087	42.557	46.693	49.588
30	14.953	16.306	18.493	20.599	23.364	25.508	29.336	33.530	36.250	40.256	43.773	47.962	50.892

Note: Table III was abridged from "Statistical Methods for Research Workers" by Fisher, published by Oliver and Boyd, Ltd., Edinburgh.

the same relative distribution of the returns, we would quite definitely reject it.

This example brings out a point about statistical tests that bears emphasis. An hypothesis is set up and a statistic calculated from the data. This statistic is compared with some statistical parameter whose probability distribution is known. The probability is the chance of getting a value as large as that observed if the hypothesis is true. If the value of the statistic is less than the parameter, it does *not* mean that the hypothesis is true. It merely sets a level to the chance of making an error if the hypothesis is rejected. Sometimes we can make statements with fairly small probability of being wrong. In other cases, it may be that there are just not enough data to make reasonably certain statements.

In the example just cited, in the first case, where we assume a 60/40 split and observe 52/48 in a sample of 100, we will make an error between one and two times out of ten if we reject the original 60/40 assumption. However, in the second case, with the same 60/40 assumption and having observed 52/48 in a sample of 1,000, we would be making an error less than once in a hundred if we reject the 60/40 assumption. The increase in the sample size, as is almost always true, has improved the quality of our statistical test.

There are two restrictions to the X^2 test. One is the test should not be used when expected frequencies are less than five. An example will be given of grouping data when one of the expected frequencies is less than five.

The other restriction is that when only one degree of freedom is involved, the difference $f - F$ is reduced by 0.5 before squaring. This is to correct for a bias in the numerical answer when the chi-squared distribution; which is a continuous mathematical function, is applied to discrete numbers. Adjustment is not necessary when the degrees of freedom exceed one. In the example previously given, the adjusted chi-squared would be

$$X^2 = \frac{[(52 - 60) - 0.5]^2}{60} + \frac{[(48 - 40) - 0.5]^2}{40}$$

$$= \frac{56.25}{60} + \frac{56.25}{40}$$

= 2.53, instead of the original 2.67.

Expected frequencies do not have to be determined before you have any data, as in the voting problem, or in testing the bias of games of chance, they may be drawn from the data themselves. The application of the chi-squared test in cases of this type is best explained by examples.

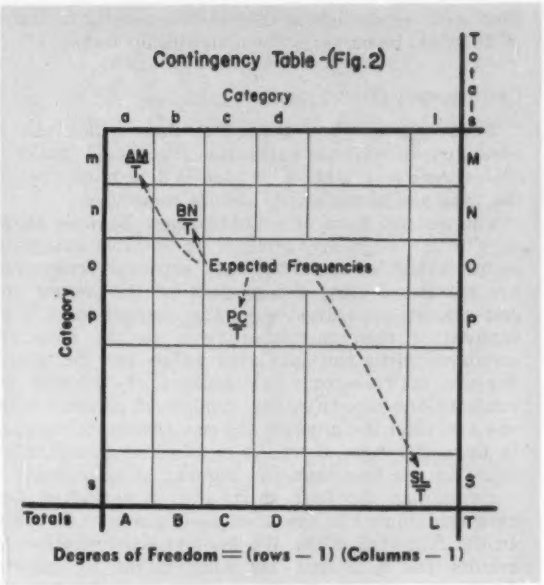
Homogeneity of Data Test

If in a series of around the clock pilot plant runs there have been 38 failures distributed over four shift groups as follows:

Shift A 9
Shift B 6
Shift C 8
Shift D 15

are we justified in saying that Shift D has had too many failures compared to the other shifts?

The expected failures from the total of 38 divided among the four shifts would be 9.5. chi-squared is



$$X^2 = \frac{(0.5)^2 + (3.5)^2 + (1.5)^2 + (5.5)^2}{9.5} = \frac{45}{9.5} = 4.74$$

With four possible categories of numbers and with the total fixed, there are three degrees of freedom. A X^2 of 4.74 at three degrees of freedom corresponds to a probability level of about 0.20. That is to say, if all the shifts were acting alike, we would expect a chi-squared value as large as 4.74 one time in five by chance alone, therefore if we say from these results that D shift are out of line, there is a 20% chance of our being wrong.

Suppose that the runs continue until there are 20 more failures, and that the distribution among shifts stays the same. Now the results will be

Shift A 14
Shift B 9
Shift C 12
Shift D 23

and the expected value will be 58/4 = 14.5. Therefore, chi-squared now calculates to be

$$X^2 = \frac{(0.5)^2 + (5.5)^2 + (2.5)^2 + (8.5)^2}{14.5} = \frac{109}{14.5} = 7.5$$

This chi-squared value, at three degrees of freedom, approaches the 0.05 level and there is only that chance of getting this distribution if the shifts were in fact operating the same.

The examples illustrate that the same relative distribution of data produces a different statistical conclusion when there are different amounts of data. Chi-squared, in fact, varies directly with the sample size when the relative distribution within the sample is unchanged. From this relation it is possible to determine the sample necessary to give a significant test.

For example, if a sample of 20 gives a chi-squared of 2.0, and a chi-squared value of 4.0 would be significant for a test you were trying to demonstrate,

then with no change in the relative results, a sample of 40 would be necesary for a significant test.

Contingency Test

A chi-squared test applied to data which can be arranged in various categories, is usually called a *contingency test.* Here X^2 is used to determine whether the data are homogeneous *within* themselves.

The general form of a Contingency Table is shown in Fig. 2. Data are grouped in suitable categories in rows and columns and the expected frequencies are calculated from the product of the proper row and column total divided by the over-all total. Chi-squared is then calculated from all the data and compared with the tabulated value for the proper degrees of freedom. The degrees of freedom are equal to one less than the number of columns times one less than the number of rows (except when there is only one row, then the degrees of freedom are equal to one less than the number of columns).

Supposing our four shifts over a period of time have contributed to the pilot plant program as shown in the following table. We want to know whether the results (as a group) are what might be expected from a normal fluctuation of experimental hazards, or are some of the shifts producing more or less than their reasonable share.

	Shifts				
Runs	A	B	C	D	Totals
Started	20	18	14	12	64
Continued	16	14	20	14	64
Discontinued	1	0	2	1	4
Successful	9	4	12	11	36
Failed	2	16	8	6	32
Totals	48	52	56	44	200

Applying the formula from the contingency table, the expected results, if the data were completely homogeneous would be

$$\text{(For shift A, R. S.} = \frac{64 \times 48}{200} = 15.4\text{):}$$

	Shifts			
Runs	A	B	C	D
Started	15.4	14.6	17.9	14.1
Continued	15.4	16.6	17.9	14.1
Discontinued	1.0	1.0	1.1	0.9
Successful	8.6	9.4	10.1	7.9
Failed	7.7	8.3	9.0	7.0

To apply the chi-squared test to these data, take, for each category, the squares of the difference between the observed and the expected value divided by the expected value and sum these for X^2.

$$X^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

However, we've said that in calculating X^2 all expected values must be at least five. The expected values for "Runs Discontinued," because of the small total in this classification, are all less than 5. This difficulty can be overcome by combining the "Runs Discontinued" into some other category, or by eliminating it from the table.

If we combine with the "Runs Terminated Successfully" group we get two new tables of observed and expected values which are the same as the first tables except that the third and fourth rows of each are combined into one row. Chi-squared can now be calculated as follows, reading down each column starting at the left.

$$\begin{aligned}
(4.6)^2/(15.4) &= 1.37 \\
(0.6)^2/(15.4) &= 0.02 \\
(0.4)^2/(9.6) &= 0.02 \\
(5.7)^2/(7.7) &= 4.22 \\
(1.4)^2/(16.6) &= 0.12 \\
(2.6)^2/(16.6) &= 0.41 \\
(6.4)^2/(10.4) &= 3.92 \\
(7.7)^2/(8.3) &= 7.14 \\
(3.9)^2/(17.9) &= 0.85 \\
(2.1)^2/(17.9) &= 0.25 \\
(2.8)^2/(11.2) &= 0.76 \\
(1.0)^2/(9.0) &= 0.11 \\
(2.1)^2/(14.1) &= 0.31 \\
(0.1)^2/(14.1) &= 0.00 \\
(3.2)^2/(8.8) &= 1.16 \\
(1.0)^2/(7.0) &= 0.14 \\
\hline
X^2 &= 20.80
\end{aligned}$$

For nine degrees of freedom (4 rows — 1) (4 columns — 1), a chi-squared value of 20.80 corresponds to a probability of 0.01 to 0.02, i.e., there is about one chance in a hundred that this distribution is homogeneous.

Since the largest contributions to X^2 are from the A and B shifts, we can reliably state that the A and B shifts are operating significantly different from the rest of the data with respect to runs that failed.

Here's another example. Ten samples of 100 catalyst pellets taken periodically from a reactor, supposed to contain a 2:1 ratio of A to B, had the following counts:

	Pellet		
Sample	A	B	X^2
1	68	32	0.048
2	69	31	0.18
3	68	32	0.048
4	69	31	0.18
5	69	31	0.18
6	68	32	0.048
7	68	32	0.048
8	69	31	0.18
9	69	31	0.18
10	68	32	0.048

None of these samples is suspect—they are all at least at the 0.90 level. However the total X^2 equals 1.14 for 10 degrees of freedom (1 from each pair) which is greater than the 0.99 level, or there is less than one chance in a hundred of getting a X^2 this *small.* The total of all the samples; 685A and 315B pellets, gives a reasonable X^2 of 1.46 for one degree of freedom. Summed chi-squared suggests that either the individual counts were made to conform with the expected result, or that the actual distribution is not 2:1. However, in the latter case, the randomness that would ordinally be present is lacking and hence the first hypothesis is more likely.

Confidence Range of s

There is one more use of chi-squared we will mention. Chi-squared can be written as in the following formula:

$$X^2 = \frac{(\text{d.f.})\, s^2}{\sigma^2}$$

where d.f. is the degrees of freedom used to calculate s^2 and s^2 is the square of the estimated standard deviation, called the estimated variance, and where σ^2 is the true variance. From this relation we can

calculate the range within which lies the true variance, and hence the true standard deviation, i.e.

$$\sigma^2 = (\text{d.f.})\frac{s^2}{X^2}$$

$$\sigma = \sqrt{(\text{d.f.})\frac{s^2}{X^2}}$$

Remember that the X^2 table lists values for low and high probability values. In other words 90% of the X^2 distribution lies in the range 0.95 to 0.05, and 96% lies in the range 0.98 to 0.02, etc. In setting the 90% probability range of the true variance from the estimated variance we may say that it has only a 5% chance of being smaller than (d.f.) $(s^2)/X^2_{0.05}$ and a 5% chance of being larger than (d.f.) $(s^2)/X^2_{0.95}$.

When we set the confidence range of the true mean we wrote:

$$m = \bar{x} \pm ts$$

this may just as well have been written:

$$\bar{x} - ts \leqq m \leqq \bar{x} + ts$$

also we may write for the variance

$$(\text{d.f.})\frac{s^2}{X^2_\epsilon} \leqq \sigma^2 \leqq (\text{d.f.})\frac{s^2}{X^2_{1-\epsilon}}$$

where ϵ is the probability listed in the X^2 tables.

For example, if we calculate an estimated standard deviation of the mean of 10 items to be 7.4 and we wish to set the 96% confidence range for the true standard deviation we proceed as follows:

$$s = 7.4$$
$$\text{d.f.} = 9$$
$$s^2 = 54.76$$
$$\epsilon = 0.02$$
$$1 - \epsilon = 0.98$$
$$X^2_{0.98,\text{d.f.}=9} = 2.532$$
$$X^2_{0.02,\text{d.f.}=9} = 19.679$$
$$\frac{(9)(54.76)}{19.679} \leqq \sigma^2 \leqq \frac{(9)(54.76)}{2.532}$$
$$25.1 \leqq \sigma^2 \leqq 195$$
$$5.0 \leqq \sigma \leqq 14.0$$

i.e. the standard deviation may, with 96% probability, be stated to be from 5.0 to 14.0.

Best Curve From Your Data

A set of pairs of numbers belonging to a straight line function do not always lie on the straight line. The deviations from the line supply very useful information.

Before getting into correlation and curve fitting, let's take up two quick correlations that may be useful when the time for a detailed numerical correlation isn't available.

Rank Correlation Test

The first of these is the Rank Correlation. In this a series of items is ranked in some order—numbered in series, and then some characteristic is also ranked for each of the items in the first series. It's then a simple matter to see if there is a correlation between two sets of rankings. The procedure is to list the two rankings and to calculate the difference between them for each item. From these differences, the rank correlation coefficient is calculated

$$R = 1 - \frac{6\Sigma d^2}{n(n^2 - 1)}$$

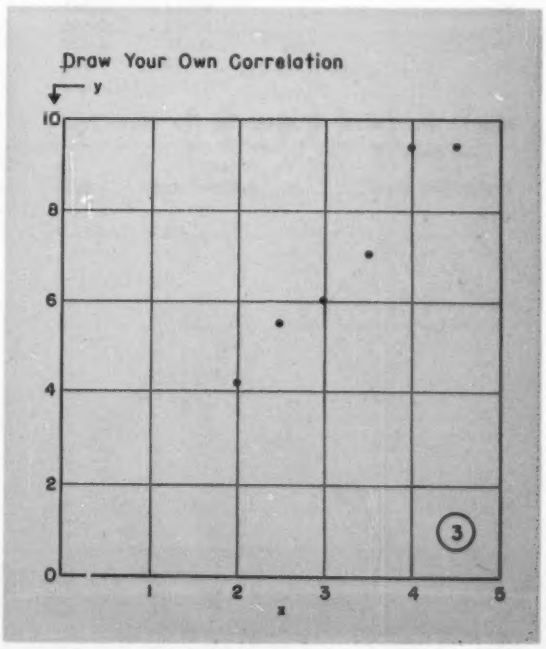
where R is the rank correlation coefficient, d is the difference between each pair of rankings and n is the number of pairs of rankings.

Then R is compared with the values in Table IV. If it *equals* or *exceeds* the value tabulated, then we can say, with the indicated probability of being wrong, that there is a correlation. If R calculated as above comes out negative, that indicates there is a reverse correlation.

For instance, suppose you have eight pairs of rankings, and you calculate an R value of 0.62. Going into Table IV, you'll see that the table value for n equals eight is 0.853 at the 1% probability level. Since the calculated value is less then this, there is a good possibility that no correlation exists.

Correlation by Ranking

Ten petroleum companies with the largest operating income (in 1948 to shy away from any current disputes) are listed below in order of their size and



with their earnings per common share company stock.

Name	Earnings Per Share	Size Rank	Earnings Rank	Difference
S.O.N.J.	12.44	1	3	2
Soc. Vac.	4.18	2	10	8
S.O. Ind.	9.16	3	7	4
Texas Co.	12.03	4	5	1
Gulf	13.53	5	2	3
Humble	10.35	6	6	0
Shell	8.27	7	8	1
S.O. Calif.	12.42	8	4	4
Sinclair	6.76	9	9	0
Cities Svc.	17.77	10	1	9

$$R = 1 - \frac{6\Sigma d^2}{n(n^2-1)} = 1 - \frac{(6)(192)}{(10)(99)} = -0.84$$

Turning to Table IV we see that this rank correlation coefficient exceeds the 0.01 value for $n=10$.

We may say, therefore, with less than one chance in a hundred of being wrong, that there *is* an inverse correlation between the 1948 earnings per share and the size of the oil company.

If in using the Rank Correlation, two items should have the same rank, then assign the average of the two to both items. For example if two items tied for fifth place, the numbering would be ranked: 3, 4, 5.5, 5.5, 7, 8.

Rank Correlation Coefficients—Table IV

Probability level	0.05	0.01
n		
4	none	none
5	1.0	none
6	0.886	1.0
7	0.750	0.893
8	0.714	0.853
9	0.632	0.765
10	0.602	0.735
12	0.553	0.684
14	0.514	0.641
16	0.482	0.606
18	0.456	0.575
20	0.433	0.549

Maximum Lesser Quantities for Sign Test —Table V

Probability level	0.10	0.05	0.01
n			
5	1	...	...
6	1	1	...
7	1	1	...
8	2	1	1
9	2	2	1
10	2	2	1
11	3	2	1
12	3	3	2
13	4	3	2
14	4	3	2
15	4	4	3
16	5	4	3
17	5	5	3
18	6	5	4
19	6	5	4
20	6	6	4
21	7	6	5
22	7	6	5
23	8	7	5
24	8	7	6
25	8	8	6
30	11	10	8
40	15	14	12
50	19	18	16

Sign Correlation

There is another quick correlation which you can sometimes apply when comparing two process—the sign correlation.

Here you count the number of times one observation exceeds the other.

If the differences are evaluated either + or — and the likelihood of either is assumed to be the same (0.5) then the same probability laws hold as in tossing a coin. How many heads in 50 tosses would lead you to question the bias of the coin (or the tosser)?

Table V gives the 0.10, 0.05, and 0.01 probability levels for the smaller number of two possibilities for various sample sizes. In the question of 50 coin tosses, if there were less than 16 of either head or tails, you would be justified in saying this represented a less than 1 in a 100 probability, and in acting accordingly.

In general, the data to be tested are paired, i.e., the difference between two analysts, or the difference between two methods, etc., and the differences are indicated by sign, either positive or negative. The lesser of the two signs are counted and compared to Table V. If for a given sample size the lesser number is *smaller* than in the Table, then there is the indicated probability that the count could occur by chance alone.

In Example 2 for the *t*-test we listed seven paired analytical results of two shifts. A *t*-test indicated that there was less than one chance in a hundred that there was no difference between shifts. In the example there were seven differences, all negative, i.e. the number of positive differences was zero. In Table V this corresponds to a probability level of 0.05. So that with this quicker test, we could have stated there was less than one chance in 20 that no difference existed between shifts.

Correlation and Regression

Probably the most interesting, and perhaps even the most useful statistical tool for the chemical engineer is the correlation of one variable with others. How does the octane number vary with bromine number and aniline point? How does the yield vary with reactant partial pressure and temperature? How do earnings vary with years of schooling and years of experience?

Let us start with the simplest case: one dependent and one independent variable—reaction rate and pressure. The usual procedure is to plot the data and draw what appears to be the best line through the points. Before going further we suggest you draw in your usual way a straight line through the points plotted in Fig. 3.

Later we will draw the "best" line by statistical methods and see how well they agree.

The "best" line in a statistical sense is the line which minimizes the sum of the squares of deviations of observed points from the line. This is similar to the way the mean of a group of data minimizes the scatter of the data when measured as the sum of squares of deviation.

Remember that the sum of squares of deviation from the mean divided by the degrees of freedom is the variance. For a correlation line, the sum of squares of deviation from the line divided by the degrees of freedom gives the residual variance—the

variance that remains after removal of the variance accounted for by the correlation, $s^2\ (Y)$.

Least Square Line

For a simple linear correlation the well known "least squares" line is the correlation giving the minimum squared deviation of the data from the line.

The equation of the "least square" line can be

$$y = a + b(x - \bar{x})$$

where

$a = \bar{y}$, the mean value of y

and

$$b = \frac{\Sigma(\bar{x} - x)(\bar{y} - y)}{\Sigma(\bar{x} - x)^2}, \text{ the slope}$$

The slope expression is obtained by differentiating the linear equation and setting the sum of squares of the derivation at a minimum.

The only new term involved here is $\Sigma\ (\bar{x}\text{-}x)\ (\bar{y}\text{-}y)$. $\Sigma\ (\bar{x}\text{-}x)^2$ or $\Sigma\ (\bar{y}\text{-}y)^2$ gives the sum of the square of the deviation of either x or y from the corresponding mean. $\Sigma\ (\bar{x}\text{-}y)\ (\bar{y}\text{-}y)$ gives the sum of the product of the deviation of each term from its mean. Let's work out a numerical example.

It's important to keep this in mind: While the calculation of the correlation line does involve some amount of work in making the numerical computation, it's considerably less than the work involved in getting the data.

If the data were worth obtaining, you should try to get the maximum amount of information out of them. Also, we will show the least squares calculation not only provides the best line, but gives information on the statistical significance of the correlation, i.e. whether the amount of scatter removed by the correlation is more than could be expected by chance; provides a basis for setting confidence ranges to the slope and intercept similar to the confidence ranges calculated for means; and finally provides for making confidence statements about predictions for other data points which might be subjected to the same correlation.

Table VI gives the formulas involved in calculating a linear correlation for one dependent and one independent variable. These formulas are illustrated in the following example which is taken from the data given in Fig. 3.

Example 4—Linear Correlation of Two Variables

y	x
4.27	2
5.60	2.5
6.03	3
7.03	3.5
9.42	4
9.40	4.5

$$\Sigma x = 19.5 \qquad \bar{x} = \frac{19.5}{6} = 3.25$$

$$\Sigma x^2 = 67.75$$

$$\Sigma(\bar{x} - x)^2 = \Sigma x^2 - \frac{(\Sigma x)^2}{n} = 67.75 - \frac{(19.5)^2}{6} = 4.375$$

$$\Sigma y = 41.65 \qquad \bar{y} = \frac{41.65}{6} = 6.9416$$

$$\Sigma y^2 = 311.6271$$

$$\Sigma(\bar{y} - y)^2 = \Sigma y^2 - \frac{(\Sigma y)^2}{n} = 311.6271 - \frac{(41.65)^2}{6}$$

$$= 22.50946$$

$$\Sigma xy = 145.015$$

$$\Sigma(\bar{x} - x)(\bar{y} - y) = \Sigma xy - \frac{\Sigma x \Sigma y}{n} = 145.015 - \frac{(19.5)\ (41.65)}{6}$$

$$= 9.6525$$

$$y = a + b\ (x - \bar{x})$$

$$a = \bar{y} = 6.9416$$

$$b = \frac{\Sigma(\bar{x} - x)(\bar{y} - y)}{\Sigma(\bar{x} - x)^2} = \frac{9.6525}{4.375} = 2.20628$$

$$y = 6.9416 + 2.20628\ (x - 3.25)$$

$$y = -0.2288 + 2.2063x$$—This is the least square line.

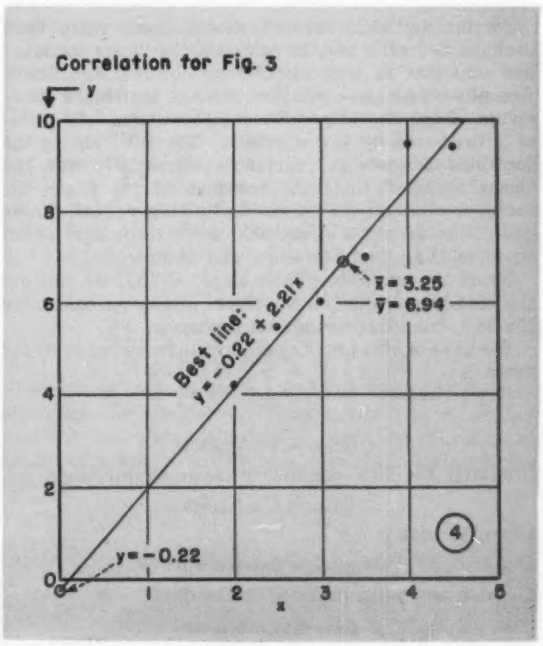
Fig. 4 shows the data of Fig. 3 with the "least square" line given by the equation $y = -0.2288 + 2.2063x$. Compare this line with the line you drew "by eye" through the same data in Fig. 3.

A "least squares" line may be drawn in several simple ways once the calculation is completed. The line goes through $\bar{x}$, $\bar{y}$, and the y intercept and may most easily be drawn in this manner. If the intercept is off the figure, the line may be drawn through the $\bar{x}$, $\bar{y}$ point with a slope b. The simplest way to do this is to calculate the point at one "x" unit from $\bar{x}$, the corresponding y value will be $\bar{y} + b$; i.e. draw the line through $\bar{x}$, $\bar{y}$ and $(\bar{x} + 1)$, $(\bar{y} + b)$.

In all cases the best line goes through $\bar{x}$, $\bar{y}$. So if you don't want to take the fifteen or so minutes required to calculate the slope, and you insist on drawing the line by eye, you will always be correct if you draw the line through $\bar{x}$, $\bar{y}$ and incorrect if you don't do this.

How Good Is Correlation?

In the data of Example 4 the correlation of y upon x is obvious and the calculation of r^2, the fraction of the variance removed by the correlation shows $r^2 = b^2$ $\Sigma\ (\bar{x}\text{-}x)^2/\Sigma\ (\bar{y}\text{-}y)^2 = (2.2063)^2\ (4.375)/(22.5095) =$



Why Is It for You?

It's wasteful to spend much valuable time and money in collecting engineering data, and then only extract a small part of the information in the data. Modern statistical methods will give the maximum amount of information—on precision, on differences between sets of data, on what component is causing process variations.

0.944 i.e. 94.4% of the scatter or variance of the original data is removed by the correlation and there is only about 5% of the scatter unaccounted for or attributable to variation in analysis.

In many cases correlations will not be this good and the question arises as to when a correlation is not significant, i.e. when the amount of variance removed by the correlation is less than could be expected by chance. This amount varies with the quantity of data involved and the significance level employed.

Table VII gives the values of r^2 for linear correlation of a dependent variable against one and two independent variables for the 95% and the 99% significance level. The correlation is a good one, if r^2, the fraction of variance removed by the correlation, is as *large* or *larger* than indicated in Table VII—then there is only a 5% chance for the 95% level or a 1% chance for the 99% level of getting this good a correlation when there was in fact *no* correlation.

In Example 4, with 4 degrees of freedom, we have $r^2 = 0.944$ which is better than 99% significant.

A Powerful Tool

So far statistics haven't shown much more than perhaps an easier way to calculate the "least squares" line and how to test whether or not it's significant. Actually we are in a position to make confidence statements about the slope, the intercept, and any value of y predicted by the equation. Table VI shows the formulas for several variances connected with the "least squares" line: the variance of the slope, the variance of $\bar{y}$ and the variance of a single point. These quantities permit a great deal more to be said about the line than just its slope and intercept.

From the variance of the slope, $s^2(b)$, we can get the confidence range on the slope, just as we calculated the 95% confidence range on the mean.

We have shown that the 95% confidence range of the mean is:

$$(\bar{x})_{0.95} = \bar{x} \pm t_{0.95}\, s(\bar{x})$$

Similarly the 95% confidence range on the slope,

$$(b)_{0.95} = b \pm t_{0.95}\, s(b)$$

Likewise with $\bar{y}$

$$(\bar{y})_{0.95} = \bar{y} \pm t_{0.95}\, s(\bar{y})$$

Or with any point included in the data

$$y_{i0.95} = y_i \pm t_{0.95}\, s(y_i)$$

Likewise the significance of the correlation can be tested by determining whether the slope is significantly different from zero

$$t = \frac{b - 0}{s(b)}$$

in the same manner that the mean difference was tested by the formula

$$t = \frac{\bar{x} - 0}{s(\bar{x})}$$

Let's see what this means in terms of our example (see Table VI for formulas):

$s^2(Y)$, residual variance $= 1/4\,[22.50946 - (2.02628)\,(9.6525)]$
$= 0.30329$
$s^2(b)$, variance of slope $= 0.30329/4.375 = 0.0693$
$s^2(\bar{y})$, variance of mean $= 0.30329/6 = 0.05055$
$s^2(y_i)$, variance of a single point
say $y_i = 2$
$x_i = (2 + 0.2288)/2.20628 = 1.009$

$$s^2(y_i) = 0.30329\left(1/6 + \frac{(3.25 - 1.009)^2}{4.375}\right)$$

$= 0.3885$
$t(0.05,\ \text{d.f.} = 4) = 2.78$

Confidence ranges would be:
on slope $= ts(b) = (2.78)\ \sqrt{0.0693} = \pm 0.730$
on $\bar{y}$ $= ts(\bar{y}) = (2.78)\ \sqrt{0.05055} = \pm 0.625$
on y_i $= ts(y_i) = (2.78)\ \sqrt{0.3855} = \pm 1.732$
i.e. $b_{0.95} = 1.476$ to 2.936
$\bar{y}_{0.95} = 6.317$ to 7.567
$y_i = 0.268$ to 3.732

This information is shown in Fig. 5 where the range of the slope and the 95% confidence range of the line are indicated. The rather wide range of the confidence belt is due to the correlation being drawn from only six data points, four degrees of freedom.

Comparison of Two Slopes

The variance of the slope permits a comparison of two correlation lines in the same way that two means were compared by the t-test. The t-test for two means was

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s(\bar{x})}$$

similarly, the test for two slopes is

$$t = \frac{b_1 - b_2}{s(b)}$$

where $s(b) =$

$$\sqrt{\frac{(\text{d.f.})_1\, s^2(Y_1) + (\text{d.f.})_2\, s^2(Y_2)}{(\text{d.f.})_1 + (\text{d.f.})_2}\left(\frac{1}{\Sigma\,(x_1 - x_1)^2} + \frac{1}{\Sigma\,(x_2 - x_2)^2}\right)}$$

One additional remark about the confidence range of a predicted point. The formula

$$s^2(y_i) = s^2(Y)\left(\frac{1}{n} + \frac{(\bar{x} - x_i)^2}{\Sigma\,(\bar{x} - x)^2}\right)$$

applies to any point included in the data obtained. If now, the calculated correlation is to be used to predict what will occur if another set of data points is to be obtained, then to this equation must be added the variance of the correlation $s^2(Y)$ so that the variance of a predicted point becomes

$$s^2(y_p) = s^2(Y)\left(\frac{1}{n} + \frac{(\bar{x} - x_p)^2}{\Sigma\,(\bar{x} - x)^2}\right) + s^2(Y)$$

$$= s^2(Y)\left(1 + \frac{1}{n} + \frac{(\bar{x} - x_p)^2}{\Sigma\,(\bar{x} - x)^2}\right)$$

Formulas for Calculating Linear Correlations — Table VI

Equation	$y=a+b(x-\bar{x})$	$y=a+b_1(x_1-\bar{x}_1)+b_2(x_2-\bar{x}_2)$
Dependent variable	y	y
Independent variables	x	x_1, x_2
No. of sets of data	n	n
Degrees of freedom	$n-2$	$n-3$
a	$\bar{y}$	$\bar{y}$
b	$\Sigma(\bar{x}-x)^2(\bar{y}-y)/\Sigma(\bar{x}-x)^2$	
b_1		$C_{11}\Sigma' x_1 y + C_{12}\Sigma' x_2 y$
b_2		$C_{12}\Sigma' x_1 y + C_{22}\Sigma' x_2 y$
Simplifying nomenclature		
	$\Sigma(\bar{x}-x)(\bar{y}-y)=\Sigma xy-\frac{(\Sigma x)(\Sigma y)}{n}$	$\Sigma' x^2$ for $\Sigma(\bar{x}-x)^2$
		$\Sigma' xy$ for $\Sigma(\bar{x}-x)(\bar{y}-y)$
	$\Sigma(\bar{x}-x)^2=\Sigma x^2-\frac{(\Sigma x)^2}{n}$	C_{11} for $\Sigma' x_2^2/K$
		C_{22} for $\Sigma' x_1^2/K$
		C_{12} for $-\Sigma' x_1 x_2/K$
		$K=\Sigma' x_1^2\Sigma' x_2^2-(\Sigma' x_1 x_2)^2$
r^2 = fraction of variance removed by correlation =	$b^2\Sigma(\bar{x}-x)^2/\Sigma(\bar{y}-y)^2$	$(b_1\Sigma' x_1 y + b_2\Sigma' x_2 y)/\Sigma' y^2$
$s^2(Y)$ = residual variance from correlation =	$\frac{1}{\text{d.f.}}\left[\Sigma(\bar{y}-y)^2-b\Sigma(\bar{x}-x)(\bar{y}-y)\right]$	$\frac{\Sigma' y^2(1-r^2)}{\text{d.f.}}$
$s^2(a)$ = variance of $\bar{y}$ =	$s^2(Y)/n$	$s^2(Y)/n$
$s^2(b)$ = variance of slope =	$s^2(Y)/\Sigma(\bar{x}-x)^2$	
$s^2(b_1)$		$C_{11}s^2(Y)$
$s^2(b_2)$		$C_{12}s^2(Y)$
r = correlation coefficient =	$\frac{\Sigma(\bar{x}-x)(\bar{y}-y)}{\sqrt{\Sigma(\bar{x}-x)^2\Sigma(\bar{y}-y)^2}}$	
$s^2(y_1)$ = variance of single point =	$s^2(Y)\left[\frac{1}{n}+\frac{(\bar{x}-x_1)^2}{\Sigma(\bar{x}-x)^2}\right]$	$s^2(Y)\left[\frac{1}{n}+C_{11}(x_1-\bar{x}_1)^2+C_{22}(x_2-\bar{x}_2)^2+2C_{12}(x_1-\bar{x}_1)(x_2-\bar{x}_2)\right]$

Lines Through the Origin

There are cases when it may be assumed a correlation goes through the zero-zero point of the curve: when plotting fraction reacted against concentration, or yield versus time, etc. In this case the calculations are simpler than those just given. The following table shows the equation corresponding to those in Table VI for the case when the intercept is known.

Equation $y = bx$

b = slope = $\dfrac{\Sigma xy}{\Sigma x^2}$

d.f. = degrees of freedom = $n - 1$

$s^2(Y)$ = residual variance = $\dfrac{1}{\text{d.f.}}(\Sigma y^2 - b\Sigma xy)$

$s^2(b)$ = variance of slope = $s^2(Y)/\Sigma x^2$

r^2 = fraction of variance removed by the correlation

$= \dfrac{b\Sigma xy - \bar{y}\Sigma y}{\Sigma y^2 - \bar{y}\Sigma y}$

Computations

A word about the computation involved in calculating the correlation. The basic quantities required are Σx, Σy, Σx^2, Σy^2, Σxy. In some cases these may all be obtained in one series of operations on a desk calculating machine by putting x in the left side and y in the right side of both the multiplier and the multiplicand (the number multiplied) and accumulating the sums. Σx and Σy will be on one set of dials and Σx^2, 2 Σxy and Σy^2 will be on the other set of dials. Suitable precaution must be taken to avoid overlapping the results.

In any case, the five sums may be obtained in three operations. It's advisable to carry all sums to two more significant figures than the base data until you have the final results. Some of the computations involve the difference between two similar quantities and rounding off may cause loss of important figures.

Also the computations may often be simplified by subtracting a constant from the x's and the y's, not necessarily the same constant from each variable. For example, the data for Example 4 might have been

x	y
52.0	104.27
52.5	105.60
52.0	106.03
etc.	etc.

Subtracting 50 from the x's and 100 from the y's does not affect the correlation. It's important to remember that the calculated equation is based on the adjusted values of x and y, and in this case the calculated correlation would be

$$y' = a + b\,(x' - \bar{x}) \text{ where } \begin{matrix} y' = y - 100 \\ x' = x - 50 \end{matrix}$$

and that the final equation must be uncoded thus:

$$\text{or} \quad \begin{matrix} y - 100 = a + b\,(x - 50 - \bar{x}) \\ y = (a + 100 - (50 + \bar{x})b) + bx \\ y = A + bx \end{matrix}$$

Multiple Correlations

A similar procedure may be followed for any number of independent variables. The method is fairly involved for more than two independent variables and in cases of that kind it would be best to refer to one of the texts listed at the end of this report. For two independent variables the procedure is outlined in the balance of this section.

Several new symbols are employed in the calculations: C_{11}, C_{22}, etc. The functions represented by these symbols are used in the solution of the three variables example although the problem could be solved without them. However, for problems with more than three variables, the solution without using these functions is extremely difficult and the symmetry illustrated by the three variable problem is followed for additional variables.

The following data gives the octane number of the gasoline yield for a number of runs under similar operating conditions but with different amounts of purity of the catalyst and at different carbon levels on the catalyst. Problem is to determine the correlation of octane numbers with impurity and carbon level, and to predict the octane number at a reasonable purity of 98% and at a carbon level of 5%.

Octane Number	Purity, %	Carbon Level, %
y'	x'_1	x_2
88.6	99.8	3
86.4	99.7	10
87.2	99.6	7
88.4	99.5	2
87.2	99.4	5
86.8	99.3	6
86.1	99.2	8
87.3	99.1	3
86.4	99.0	5
86.6	98.9	4
87.1	98.8	2

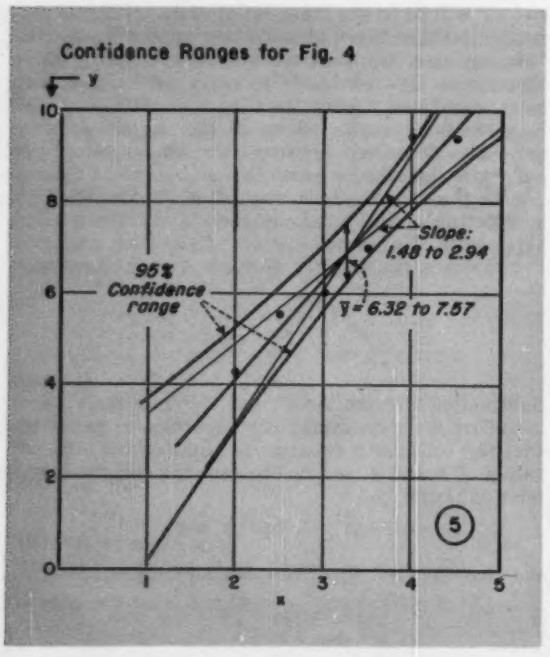


Table VI also lists the equations involved in a three variable correlation.

In calculating the correlation equation, 80 may be subtracted from all the y' values, giving a coded variable y and a new x_1 equal to $100 - x'_1$ may be substituted for % purity to simplify the arithmetic.

The following represents the steps in the solution. A complete computation of all the numbers given below was done in thirty minutes, on an electric desk calculating machine.

Example 5—Linear Correlation of Three Variables

y	x_1	x_2
8.6	0.2	3
6.4	0.3	10
7.2	0.4	7
8.4	0.5	2
7.2	0.6	5
6.8	0.7	6
6.1	0.8	8
7.3	0.9	3
6.4	1.0	5
6.6	1.1	4
7.1	1.2	2

$n = 11$

Taking sum of:

$y = 78.1000 \qquad \bar{y} = 7.1000$

$y^2 = 560.8300$

$x_1 = 7.7000 \qquad \bar{x}_1 = 0.7000$

$x_1^2 = 6.4900$

$x_2 = 55.0000 \qquad \bar{x}_2 = 0.5000$

$x_2^2 = 341.0000$

$x_1y = 53.4300$

$x_2y = 377.1000$

$x_1x_2 = 35.5000$

$\Sigma' y^2 = \Sigma y^2 - \bar{y}\Sigma y = 6.3200$

$\Sigma' x_1^2 = \Sigma x^2 - \bar{x}_1\Sigma x_1 = 1.1000$

$\Sigma' x_2^2 = \Sigma x_2^2 - \bar{x}_2\Sigma x_2 = 66.0000$

$\Sigma' x_1y = \Sigma x_1y - \bar{x}_1\Sigma y = 1.2400$

$\Sigma' x_2y = \Sigma x_2y - \bar{x}_2\Sigma y = -13.4000$

$\Sigma' x_1x_2 = \Sigma x_1x_2 - \bar{x}_1\Sigma x_2 = -3.0000$

$K = 63.6000$

$C_{11} = 1.0377$

$C_{22} = 0.017296$

$C_{12} = 0.047170$

d.f. $= n - 3 = 8$

$b_1 = -1.9188$

$b_2 = -0.2903$

$r^2 = 0.9920$

$s^2(Y) = 0.006320$

$s^2(b_1) = 0.006558$

$s^2(b_2) = 0.000109$

$$y = a + b_1(x_1 - \bar{x}_1) + b_2(x_2 - \bar{x}_2)$$
$$= 7.100 - 1.9188(x_1 - 0.700) - 0.2903(x_2 - 5.0000)$$
$$= 5.5142 - 1.9188x_1 - 0.2903x_2$$

putting $y' = y + 80$

$x'_1 = 100 - x_1$

$$y' = 85.5142 - 191.88 + 1.9188x'_1 - 0.2903x_2$$
$$y' = -106.37 + 1.92x'_1 - 0.29x_2$$

(Final regression line).

$s(b_1) = 0.0810$

$s(b_2) = 0.0104$

The equation relating octane number to impurity in the catalyst and carbon level is shown to be

O.N. $= -106.37 + 1.92$ (% Purity) -0.29 (% Carbon)

The amount of variance removed by the correlation is given by $r^2 = 0.992$. Referring to Table VII where the significant r^2 values for two independent variables are also listed, we see that for 8 degrees of freedom, a r^2 greater than 0.684 is 99% significant so that our correlation is quite good.

The confidence ranges on the individual slopes b_1 and b_2 can be obtained in a manner exactly similar to that for the equation with one independent variable

$$b \pm ts(b)$$

where t is taken from Table I at the proper degrees of freedom and probability level. For example the 95% confidence range on b_1 is

$$1.92 \pm (2.31)\ (0.0810), \text{ or from } 1.73 \text{ to } 2.11.$$

Curvilinear Correlations

Correlations, of course, don't have to be linear although the linear ones are most frequently employed and are definitely most easily handled. It is often possible to modify non-linear formulas to give linear equations. The most common example is to transform exponential equation to linear legarithmetic equation.

$$y = ab^x$$
$$\log y = \log a + x \log b$$
$$Y = A + Bx$$

It's also possible to fit least squares lines to non-linear equations of the form

$$y = A + Bx + Cx^2 + Dx^3 + \ldots \text{ etc.}$$

Several of the texts listed at the end of this article give the details for least squaring this type of equation. The method is of course more involved than for the simple linear equations, but the procedures have been established for stepwise solution and are easily followed.

Correlation Not Casual Relation

One last word before we leave the subject of correlation. It is important to know that correlation does not signify a cause and effect relation. If we correlate the starting salaries of engineers with the price of cigarettes (or alcohol) it does not signify that one is the cause of the other; they may both be the result of some other unnamed variable. The test of significance indicates whether the correlation between the variables is better than could be expected by chance. It cannot establish the casual relation between the variables.

Fraction of Variance Removed by Correlation (r^2)—Table VII

	One Independent Variable		Two Independent Variables	
Significance Level	**0.95**	**0.99**	**0.95**	**0.99**
d.f.				
1	0.994	1.000	0.998	1.000
2	0.902	0.980	0.951	0.990
3	0.771	0.920	0.865	0.953
4	0.658	0.841	0.776	0.901
5	0.569	0.764	0.699	0.841
6	0.500	0.696	0.632	0.785
8	0.399	0.585	0.527	0.684
10	0.332	0.501	0.450	0.602
12	0.283	0.437	0.393	0.536
15	0.232	0.367	0.329	0.458
20	0.179	0.288	0.259	0.370
25	0.145	0.237	0.213	0.308

If r^2 exceeds the tabulated value for the correct degrees of freedom, then the correlation is significant at the indicated probability level.

Most Powerful—Analysis of Variance

The importance of the analysis of variance to the chemical engineer is this: it makes possible separation of the total variance of a process into its component parts.

We have discussed the t function for testing whether the means of two sets of data could reasonably be considered to be measures of the same quantity.

Statistics also provides a function for testing whether the scatter of two sets of data—as measured by the variance—is such as would be expected from two samples from the same population. This test is the F-test, after R. A. Fisher, originator of much of today's statistics.

Comparison of Two Variances

The procedure is similar to that followed in the t-test. A null hypothesis, that $s_1^2 \leqq s_2^2$, is set up and F calculated from the two variances, $F = s_1^2/s_2^2$. If the calculated F exceeds the expected value then with the indicated probability of error, we may reject the null hypothesis.

The comparison with the t-test is indicated as follows:

	t-test	F-test
Null hypothesis	$\bar{x}_1 = \bar{x}_2$	$s_1^2 \leqq s_2^2$
Test	$t = \dfrac{\bar{x}_1 - \bar{x}_2}{s(\bar{x})}$	$F = \dfrac{s_1^2}{s_2^2}$

With the F-test the degrees of freedom corresponding to the two variances need not be identical. In Tables VIII and IX you'll find F values for 0.05 and 0.01 probability levels. Across the top of the table are the degrees of freedom for the variance in the numerator. And the left hand column gives the degrees of freedom for the variance in the denominator. The F values are in the body of both variance Tables VIII and IX.

For example, looking at Table VIII, if the numerator variance had 8 degrees of freedom and the denominator variance had 10, then if the F value exceeded 3.07 we could reject the hypothesis that the variances were equal with a 5% chance of being wrong. If the F exceeds 5.06 (Table IX), there would be only 1% chance of being wrong if you rejected the hypothesis of equal variance.

An example might illustrate this test more clearly. A simplified analytical procedure is proposed for a routine laboratory test. It's necessary to test not only whether the new procedure gives the same results as the old, i.e. whether the means of a duplicate set are the same; but also whether the precision of the new test—the variance or scatter of the results—is as good as the other method.

Typical Analysis—Are the Batches Homogeneous in Volatile Matter (Example 7)?

Batch	No. Samples k	Variance in Vol. Matter	$k-1$	$1/(k-1)$	$(k-1)s^2$	$\log s^2$	$(k-1)\log s^2$
1	6	1.4	5	0.2000	7.0	0.1461	0.7305
2	4	0.7	3	0.3333	2.1	−0.1549	−0.4647
3	6	0.7	5	0.2000	3.5	−0.1549	−0.7745
4	7	1.2	6	0.1667	7.2	0.0792	0.4752
5	8	1.2	7	0.1429	8.4	0.0792	0.5544
6	6	0.6	5	0.2000	3.0	−0.2218	−1.1090
7	4	1.4	3	0.3333	4.2	0.1461	0.4383
8	7	0.4	6	0.1667	2.4	−0.3979	−2.3874
8			40	1.7429	37.8		−2.5372

$$C = 1 + \frac{1}{3(7)}\left(1.7429 - \frac{1}{40}\right) = 1 + \frac{1}{21}(1.7179) = 1.0818$$

$s^2 = 37.8/40 = 0.9450 \qquad \log s^2 = -0.0246$

$$X^2 = \frac{1}{1.0818}(2.303)[(-0.0246)(40) - (-2.5372)] = \frac{2.303}{1.0818}(1.5532) = 3.30$$ There is no significant difference between batches.

Example 6—Comparison of Variances

Current Analytical Method	Revised Method
14.7	14.2
14.5	14.8
14.7	14.6
14.6	14.4
14.5	15.0
	14.7
	14.5

To simplify the arithmetic, subtract 14 from all results.

0.7	0.2
0.5	0.8
0.7	0.6
0.6	0.4
0.5	1.0
	0.7
	0.5

n	= 5	7
Σx	= 3.0	4.2
$\bar{x}$	= 0.6	0.6
Σx^2	= 1.84	2.94
$\Sigma(x-\bar{x})^2$	= 0.04	0.42
$s^2(x) = \Sigma(x-\bar{x})^2/(n-1)$	= 0.01	0.07

$F = s^2$ revised$/s^2$ current $= 0.07/0.01 = 7.0$
F (0.05, d.f.$_1 = 6$, d.f.$_2 = 4$) $= 6.09$

i.e. the difference in variance is significant at the 0.05 level, and it can be reliably (95% confidence) stated that the revised procedure is less precise than the current procedure.

This method of testing variability of a measurement can be applied to any two cases and is independent of the means of the measurements. The variability of thermocouples may be compared at two different temperature levels, for example, as the variances measure the mean squared deviations from the means, and do not include the means in their comparison.

There are many instances in engineering where the variability is at least as important as the mean value: breakdown strength of electric wire insulation, strength of synthetic fiber, life of heating elements, etc. In these, and other cases, the engineer would often be glad to sacrifice a little in the average value if the variability could be made smaller so that the quality would be more reliable.

Comparison of More than Two Variances

The F test provides a statistical measure of the variability of two sets of measurements. If there are more than two sets, statistics also has a test for determining whether the variability of the separate sets forms a homogeneous group. This test is best given by example. The statistic used is X^2 of Table III. The formula for X^2 from a group of variances is as follows:

$$X^2 = \frac{1}{C}(2.303)[(\log \bar{s}^2)\,\Sigma(k-1) - \Sigma(k-1)\log s^2]$$

$\bar{s}^2$ is the pooled variance $= \dfrac{\Sigma(k-1)\,s^2}{\Sigma(k-1)}$

k is the number of datum points used to calculate s^2

$$C = 1 + \frac{1}{3(n-1)}\left[\sum \frac{1}{k-1} - \frac{1}{\Sigma(k-1)}\right]$$

n = number of sets of data
d.f. for $X^2 = n - 1$

The X^2 calculated from the above equation is compared with the tabulated values in Table III. If the calculated value exceeds the tabulated value at (n-1) degrees of freedom, then the variances may be said to be non-homogeneous with the indicated probability of being wrong. The following example illustrates this test.

Example 7—Homogeniety of Variances

Eight batches of petroleum coke are sampled to determine the variation of volatile matter between batches (see Typical Analysis, above). A batch consists of several hundred tons and several samples are taken from each batch, to determine the variation in a batch. The question to be answered is whether the variation of volatile matter within batches is homogeneous i.e. consistent.

Referring to Table III, X^2 at 7 degrees of freedom (n-1 = 7) would have to be 14.1 to be significant at the 0.05 level. Therefore, our coke batches are not significantly different in the volatile matter variation within batches.

This calculation may appear to be somewhat for-

midable. It may be simplified in two ways. If all the batches are of the same size, i.e. all the k's are the same the formula for X^2 reduces to

$$X^2 = \frac{1}{C}\ (2.303)\ (k-1)\ (n \log \bar{s}^2 - \Sigma \log s^2)$$

and $$C = 1 + \frac{n+1}{3n\ (k-1)}$$

The effect of the C factor is always to lower the X^2 value. Therefore X^2 may be calculated without the C term and if it's not significant, then the variances may be accepted as homogenous and no further calculation made. Only if the X^2 is near to the tabulated significant value need the C factor be applied to get the exact X^2 value.

Relation of Statistical Tests

Why is X^2 used in one case to test variances and F used in another? Without going into the mathematics involved, all the statistical tests listed here are interrelated. We have previously given an equation for X^2 as

$$X^2 = \frac{(\text{d.f.})\ s^2}{\sigma^2}$$

and we say that at infinite degrees of freedom $s^2 = \sigma^2$. Therefore X^2 should correspond to F, times the degrees of freedom for values at infinite degrees of freedom in the denominator—which it does. The last row in the F Table VIII times the degrees of freedom corresponds to the X^2 values of Table III at the 0.05 level.

While we are at it, we might mention that F is related to t also in that $t^2 = F$ when one degree of freedom is associated with the numerator.

Also r^2, the fraction of variance removed by a correlation, given in Table VI is related to t^2 when two variables are involved in the following way.

$$t^2 = \frac{r^2\ (n-2)}{1-r^2}$$

How to Use F Table

The F Tables contain the maximum values that occur by chance alone at a given probability level. The tables are computed, assuming variance in the numerator cannot be smaller than that of the denominator except by chance. The limiting value of F is 1.0.

There may be cases when the relation of the variances is not set in advance. Instead of testing whether a new product has more variability than the standard, you might be testing two new products to see if either one were more or less variable than the other. In this case, the probability levels of the F tables are double, i.e. 0.10 for Table VIII and 0.02 for Table IX.

To use the F-test for two variances when one has reason to be thought larger than the other, the one to be tested is put in the numerator. If the resulting F value is less than the tabulated value (usually at probability of 0.5) with the proper degrees of freedom, the hypothesis that the variances are the same is accepted.

In using the F-test for two variances when there is no reason to assume either is the larger, the larger variance is put in the numerator and the decisions are made in the same way as in the first case but at double the probability level. If you reject the hypothesis that $s_1^2 = s_2^2$ from Table VIII, you are only 90% confident of not making an error.

Testing More Than Two Means

The t-test gave us a method for comparing two means. The F-test provides a method for comparing more than two. We have shown that if a group of samples of size n from a universe has a variance of $s^2(x)$ then the means of the samples have a variance $s^2(\bar{x}) = s^2(x)/n$. Therfore if we have several sets of measurements and want to know whether the means are similar, we calculate the pooled variance of the sets of samples, $\bar{s}^2(x)$ and the variance of the means of the sets, $s^2(\bar{x})$.

If the means have only a normal amount of variation, then $ns^2(\bar{x})/\bar{s}^2(x) = 1.0$. If the means are different, then $s^2(\bar{x})$ will include not only the variance within the sets of samples, but will include the variance due to the difference of the means and the ratio of the variances will be different from the tabulated F values. This test is the simplest form of the Analysis of Variance.

The computation of the Analysis of Variance has been elegantly systemized and is best illustrated by an example. In the example, a sum of squares of deviation from the mean is computed for each variance source and is divided by the corresponding degrees of freedom to calculate the estimated variance. This is exactly the way we calculated a simple variance.

$$s^2(x) = \Sigma(x-\bar{x})^2/(n-1)$$

We call the sum of squares of deviation from the mean the "sum of squares" for simplicity. And since the estimated variance may include more than one variance (as that is what is being tested), we call it the "mean square."

In all cases, a term will be required corresponding to the squared sum of all items divided by the number of items, $(\Sigma\ x)^2/n$: We will call this C.

The analysis of variance proceeds as follows:

Source of Variance	Degrees of Freedom	Sum of Squares
Means	No. of means − 1	$\sum \frac{(\text{Set Sums})^2}{\text{No. in Set}} - C$
Within Sets of data	Total samples − No. of means	$\Sigma x^2 - \sum \frac{(\text{Set Sums})^2}{\text{No. in Set}}$
Total	Total samples − 1	$\Sigma x^2 - C$

Example 8—*Analysis of Variance for Three Sets of Data*

Three processes give the following results and we desire to know whether the averages for the three are similar.

Process	1	2	3	
	10.4	11.4	12.1	
	11.2	11.9	11.9	
	9.8	11.8	12.4	
	10.6	10.9	12.0	
Total	42.0	46.0	48.4	136.4
Means	10.5	11.5	12.1	

$$C = \frac{(136.4)^2}{12} = 1550.41$$

$$\sum \frac{(\text{Set Sum})^2}{\text{No. in Set}} = \frac{(42.0)^2}{4} + \frac{(46.0)^2}{4} + \frac{(48.4)^2}{4} = 1{,}555.64$$

$$\Sigma x^2 = 1557.40$$

Typical Analysis of Variance Formulas

Reactors			
Temperatures	1	2	3
1	x_{11}	x_{21}	x_{31}
2	x_{21}	x_{22}	x_{32}
3	x_{31}	x_{32}	x_{33}

Source of Variance	Degrees of Freedom	Sum of Squares
Temperatures	No. rows − 1	$\frac{(\text{Row totals})^2}{\text{No. in a row}} - (\Sigma x)^2/n$
Reactors	No. columns − 1	$\frac{(\text{Column totals})^2}{\text{No. in a column}} - (\Sigma x)^2/n$
Within sets of samples (x_{11}, x_{21}, x_{31})	Total d.f. − (reactor and temp. d.f.)	Total s.s. − (reactor and temp. s.s.)
Total	Total no. samples − 1	$\Sigma x^2 - (\Sigma x)^2/n$

Source of Variance	Degrees of Freedom	Sum of Squares	s^2 Mean Square	F
Between means	2	1555.64 − 1550.41 = 5.23	2.62	13.0**
Within Sets of data	9	1557.40 − 1555.64 = 1.76	0.19	
Total	11	1557.40 − 1550.41 = 6.99		

The double asterisk on the F value indicates it is significant at the 0.01 level. From Tables VIII and IX, F (0.05, d.f.$_1$ = 2, d.f.$_2$ = 9) = 4.26 and F (0.01, d.f.$_1$ = 2, d.f.$_2$ = 9) = 8.02, i.e. the means are different at both the 0.05 level and at the 0.01 level.

The within set variance is a pooled estimate of the variance of the individual measurements. From it the standard deviation and hence precision can be calculated.

$$\text{precision} = \pm ts = t\sqrt{s^2}$$

at 0.05, d.f. = 9, t = 2.26 (Table I)

$$\text{precision} = \pm (2.26)(0.43) = \pm 0.97$$

Arithmetic of this example could have been simplified by subtracting 10 from all of the numbers without changing the result.

The mean square is an estimate of variance. The within each set of data mean square estimates the within set variance, σ_w^2. The between set mean square estimates the sum of within set variance and n times the between set variance, where n is the number in a set; $\sigma_w^2 + n\,\sigma_b^2$. What the F test does is to establish whether $n\,\sigma_b^2$ exists. When the ratio $(\sigma_w^2 + n\,\sigma_b^2)/\sigma_w^2$ is greater than the tabulated F values, then you can assume $n\,\sigma_b^2$ exists. The between set variance may then be calculated, σ_b^2 = variance between sets

$$\sigma_b^2 = [(\text{mean square between sets}) - \sigma_w^2]/n.$$

In Example 8,

Mean square between sets = 2.62
Mean square within sets = 0.19
No. in a set = 4
Between set variance = (2.62 − 0.19)/4 = 0.61

Analysis of Variance for Two Sets of Classifications

The beautiful part about the analysis of variance is that it can be applied in suitable cases to any number of classifications. For example if nine experiments were run at three temperatures and in three different reactors, by a procedure similar to that of Example 8, (see Typical Analysis above) the data could be tested to see whether the reactor mean results were similar and also the variance of the individual measurements.

If we divide the data into groups according to the classifications, the analysis of variance calculation can be followed in a formal manner.

The mean square for each category is the corresponding sum of squares divided by the proper degrees of freedom. An F test applied to each classification, comparing it with the variance within sets, will establish whether the variance due to this classification exists, i.e. whether the means are significantly different. If the variance due to one of the classifications exists, it may be calculated from the mean squares since:

Mean Squares for	Estimates Variance of
Rows	s^2 + (no. in a row) (s^2 rows)
Columns	s^2 + (no. in a column) (s^2 columns)
Within Sets of samples	s^2

The use of this technique to determine the contribution of the several steps in analysis by mass spectrometer to the precision of the result was recently published by the author[5].

Example 9 gives an example of two classification analysis of variance. The number of rows and the number of columns do not have to be the same, but all the rows must have equal amounts of data and all columns likewise must have equal amounts of information.

Example 9—Two Way Analysis of Variance

	Yields in Reactor, %			
Temperatures	1	2	3	4
1	10.6	10.7	10.9	10.4
2	11.3	11.6	12.3	11.1
3	12.7	12.9	13.2	12.1

(11.0 is subtracted from all the results in the work that follows to simplify the arithmetic)

$$C = \frac{(\Sigma x)^2}{n} = \frac{60.84}{12} = 5.070$$

$$\Sigma x^2 = 15.320$$

$$\sum \frac{(\Sigma \text{ Rows})^2}{\text{No. in Row}} = \frac{54.86}{4} = 13.715$$

$$\sum \frac{(\Sigma \text{ Columns})^2}{\text{No. in Column}} = \frac{19.32}{3} = 6.440$$

Sources of Variance	d.f.	Sum of Squares	Mean Square s^2	F
Reactors	3	1.370	0.457	11.7**
Temperatures	2	8.645	4.322	111**
Within Set	6	0.235	0.039	
Total	11	10.250		

Both of the variances are highly significant and there is an effect of both reactors and temperatures on the results.

Although no duplicates were made at any condition, we may estimate the precision of a result by the within set variance of 0.039.

Interaction Effects

In a set of experiments with two variables, the effect of the variables might be different at the different levels of each other. This effect is called "interaction." It would not be reasonable to expect that there would be an interaction between the variables temperature and reactors.

However, if experiments were run at several pressures and at several temperatures, then interaction might be expected (Fig. 6). The effect of this interaction is included in the analysis of variance in the "within set" variance.

In the illustrative example the within set variance was small and could be interpreted as a measure of the precision of the experimental process. If the within set variance were large, and it was suspected that it included an interaction effect in addition to experimental error, it would be necessary to duplicate the experiment to separate these two contributions to the variance. The experimental plan would be:

	Pressures		
Temperatures	1	2	3
1	$x\ y$	$x\ y$	$x\ y$
2	$x\ y$	$x\ y$	$x\ y$
3	$x\ y$	$x\ y$	$x\ y$
4	$x\ y$	$x\ y$	$x\ y$

Where the x's and y's indicate duplicate runs at each set of condition. These duplicate runs give an indication of pure error—independent of interaction.

Source of Variance	Degrees of Freedom	Sum of Squares
Pressures	Columns − 1	$\frac{(\text{Column Totals})^2}{\text{No. in a Column}} - C$
Temperatures	Rows − 1	$\frac{(\text{Row Totals})^2}{\text{No. in a Row}} - C$
Interaction	Subtotal − sum of pressure and temp. d.f.	Subtotal − sum of pressure and temp. s.s.
Subtotal	No. of Replicates	$\frac{(\text{Replicate Totals})^2}{\text{No. in Replicate}} - C$
Within Replicates	Total − subtotal d.f.	Total − subtotal s.s.
Total	Total − 1	$\Sigma x^2 - C$

The mean squares are calculated as before and the F test is applied to each mean square comparing it to the within replicate mean square.

Analysis of Variance for More than Two Classifications

The analysis of variance may be applied to any number of classifications if the data are collected in a suitable manner. This collection of data is the basis of the subject of experimental design, which is too involved to be dealt with in detail in the remainder of this article. Last August's *Chemical Engineering*[1] carried an interesting introduction to the subject.

For examples of more involved analysis of variance schemes, the engineer might best refer to some of the statistics text books. The procedure in each case follows the pattern set by the examples already given. The sum of each category is squared and divided by the number of terms in the sum. The over-all total of these divisions is diminished by the term $(\Sigma\ x)^2/n$.

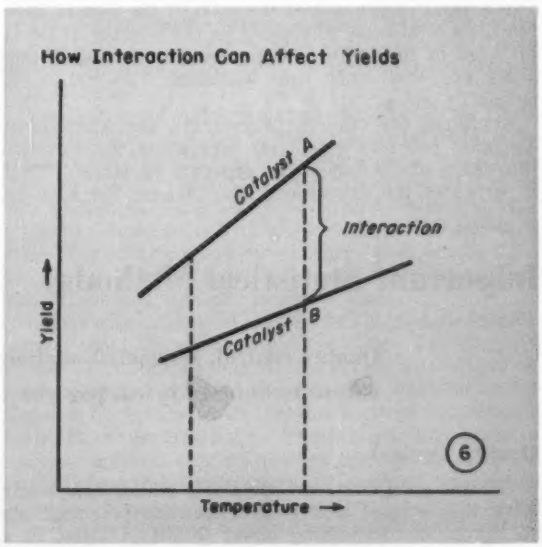
In the following arrangement, experiments were run at four temperatures and four pressures, in four reactors.

	Temperatures			
Pressures	T_1	T_2	T_3	T_4
P_1	R_3	R_4	R_2	R_1
P_2	R_1	R_3	R_4	R_2
P_3	R_4	R_2	R_1	R_3
P_4	R_2	R_1	R_3	R_4

That is, at temperature T_1, and pressure P_1, reactor 3 was employed. In this scheme each temperature and each pressure was employed once in each reactor. Sixteen runs, without duplication, serve to find the main effects of the three variables and as shown below, six degrees of freedom are available for estimating internal variance or precision.

The analysis of variance is performed as follows:

Source of Variance	Degrees of Freedom	Sum of Squares
Temperature	4 − 1 = 3	$\sum\frac{(\Sigma T)^2}{4} - C$
Pressure	4 − 1 = 3	$\sum\frac{(\Sigma P)^2}{4} - C$
Reactors	4 − 1 = 3	$\sum\frac{(\Sigma R)^2}{4} - C$
Internal	Difference, 15 − 9 = 6	Total − sum of temp., pressure, reactors.
Total	16 − 1 = 15	$\Sigma x^2 - C$



F Values at 0.05 Probability Level—Table VIII

n_1 = degrees of freedom for variance in numerator

n_2	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
1	161	200	216	225	230	234	237	239	241	242	243	244	245	246	248	249	250	251	252	253	253	254	254	254
2	18.51	19.00	19.16	19.25	19.30	19.33	19.36	19.37	19.38	19.39	19.40	19.41	19.42	19.42	19.44	19.45	19.46	19.47	19.47	19.48	19.49	19.49	19.50	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.88	8.84	8.81	8.78	8.76	8.74	8.71	8.69	8.66	8.64	8.62	8.60	8.58	8.57	8.56	8.54	8.54	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.93	5.91	5.87	5.84	5.80	5.77	5.74	5.71	5.70	5.68	5.66	5.65	5.64	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.78	4.74	4.70	4.68	4.64	4.60	4.56	4.53	4.50	4.46	4.44	4.42	4.40	4.38	4.37	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.96	3.92	3.87	3.84	3.81	3.77	3.75	3.72	3.71	3.69	3.68	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.63	3.60	3.57	3.52	3.49	3.44	3.41	3.38	3.34	3.32	3.29	3.28	3.25	3.24	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.34	3.31	3.28	3.23	3.20	3.15	3.12	3.08	3.05	3.03	3.00	2.98	2.96	2.94	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.13	3.10	3.07	3.02	2.98	2.93	2.90	2.86	2.82	2.80	2.77	2.76	2.73	2.72	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.97	2.94	2.91	2.86	2.82	2.77	2.74	2.70	2.67	2.64	2.61	2.59	2.56	2.55	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.86	2.82	2.79	2.74	2.70	2.65	2.61	2.57	2.53	2.50	2.47	2.45	2.42	2.41	2.40
12	4.75	3.88	3.49	3.26	3.11	3.00	2.92	2.85	2.80	2.76	2.72	2.69	2.64	2.60	2.54	2.50	2.46	2.42	2.40	2.36	2.35	2.32	2.31	2.30
13	4.67	3.80	3.41	3.18	3.02	2.92	2.84	2.77	2.72	2.67	2.63	2.60	2.55	2.51	2.46	2.42	2.38	2.34	2.32	2.28	2.26	2.24	2.22	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.77	2.70	2.65	2.60	2.56	2.53	2.48	2.44	2.39	2.35	2.31	2.27	2.24	2.21	2.19	2.16	2.14	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.70	2.64	2.59	2.55	2.51	2.48	2.43	2.39	2.33	2.29	2.25	2.21	2.18	2.15	2.12	2.10	2.08	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.45	2.42	2.37	2.33	2.28	2.24	2.20	2.16	2.13	2.09	2.07	2.04	2.02	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.62	2.55	2.50	2.45	2.41	2.38	2.33	2.29	2.23	2.19	2.15	2.11	2.08	2.04	2.02	1.99	1.97	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.29	2.25	2.19	2.15	2.11	2.07	2.04	2.00	1.98	1.95	1.93	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.55	2.48	2.43	2.38	2.34	2.31	2.26	2.21	2.15	2.11	2.07	2.02	2.00	1.96	1.94	1.91	1.90	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.52	2.45	2.40	2.35	2.31	2.28	2.23	2.18	2.12	2.08	2.04	1.99	1.96	1.92	1.90	1.87	1.85	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.28	2.25	2.20	2.15	2.09	2.05	2.00	1.96	1.93	1.89	1.87	1.84	1.82	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.47	2.40	2.35	2.30	2.26	2.23	2.18	2.13	2.07	2.03	1.98	1.93	1.91	1.87	1.84	1.81	1.80	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.45	2.38	2.32	2.28	2.24	2.20	2.14	2.10	2.04	2.00	1.96	1.91	1.88	1.84	1.82	1.79	1.77	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.43	2.36	2.30	2.26	2.22	2.18	2.13	2.09	2.02	1.98	1.94	1.89	1.86	1.82	1.80	1.76	1.74	1.73
25	4.24	3.38	2.99	2.76	2.60	2.49	2.41	2.34	2.28	2.24	2.20	2.16	2.11	2.06	2.00	1.96	1.92	1.87	1.84	1.80	1.77	1.74	1.72	1.71
26	4.22	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.18	2.15	2.10	2.05	1.99	1.95	1.90	1.85	1.82	1.78	1.76	1.72	1.70	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.30	2.25	2.20	2.16	2.13	2.08	2.03	1.97	1.93	1.88	1.84	1.80	1.76	1.74	1.71	1.68	1.67
28	4.20	3.34	2.95	2.71	2.56	2.44	2.36	2.29	2.24	2.19	2.15	2.12	2.06	2.02	1.96	1.91	1.87	1.81	1.78	1.75	1.72	1.69	1.67	1.65
29	4.18	3.33	2.93	2.70	2.54	2.43	2.35	2.28	2.22	2.18	2.14	2.10	2.05	2.00	1.94	1.90	1.85	1.80	1.77	1.73	1.71	1.68	1.65	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.34	2.27	2.21	2.16	2.12	2.09	2.04	1.99	1.93	1.89	1.84	1.79	1.76	1.72	1.69	1.66	1.64	1.62
32	4.15	3.30	2.90	2.67	2.51	2.40	2.32	2.25	2.19	2.14	2.10	2.07	2.02	1.97	1.91	1.86	1.82	1.76	1.74	1.69	1.67	1.64	1.61	1.59
34	4.13	3.28	2.88	2.65	2.49	2.38	2.30	2.23	2.17	2.12	2.08	2.05	2.00	1.95	1.89	1.84	1.80	1.74	1.71	1.67	1.64	1.61	1.59	1.57
36	4.11	3.26	2.86	2.63	2.48	2.36	2.28	2.21	2.15	2.10	2.06	2.03	1.98	1.93	1.87	1.82	1.78	1.72	1.69	1.65	1.62	1.59	1.56	1.55
38	4.10	3.25	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09	2.05	2.02	1.96	1.92	1.85	1.80	1.76	1.71	1.67	1.63	1.60	1.57	1.54	1.53
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.07	2.04	2.00	1.95	1.90	1.84	1.79	1.74	1.69	1.66	1.61	1.59	1.55	1.53	1.51
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.06	2.02	1.99	1.94	1.89	1.82	1.78	1.73	1.68	1.64	1.60	1.57	1.54	1.51	1.49
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05	2.01	1.98	1.92	1.88	1.81	1.76	1.72	1.66	1.63	1.58	1.56	1.52	1.50	1.48
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.14	2.09	2.04	2.00	1.97	1.91	1.87	1.80	1.75	1.71	1.65	1.62	1.57	1.54	1.51	1.48	1.46
48	4.04	3.19	2.80	2.56	2.41	2.30	2.21	2.14	2.08	2.03	1.99	1.96	1.90	1.86	1.79	1.74	1.70	1.64	1.61	1.56	1.53	1.50	1.47	1.45
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.02	1.98	1.95	1.90	1.85	1.78	1.74	1.69	1.63	1.60	1.55	1.52	1.48	1.46	1.44
55	4.02	3.17	2.78	2.54	2.38	2.27	2.18	2.11	2.05	2.00	1.97	1.93	1.88	1.83	1.76	1.72	1.67	1.61	1.58	1.52	1.50	1.46	1.43	1.41
60	4.00	3.15	2.76	2.52	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.86	1.81	1.75	1.70	1.65	1.59	1.56	1.50	1.48	1.44	1.41	1.39
65	3.99	3.14	2.75	2.51	2.36	2.24	2.15	2.08	2.02	1.98	1.94	1.90	1.85	1.80	1.73	1.68	1.63	1.57	1.54	1.49	1.46	1.42	1.39	1.37
70	3.98	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.01	1.97	1.93	1.89	1.84	1.79	1.72	1.67	1.62	1.56	1.53	1.47	1.45	1.40	1.37	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.12	2.05	1.99	1.95	1.91	1.88	1.82	1.77	1.70	1.65	1.60	1.54	1.51	1.45	1.42	1.38	1.35	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.10	2.03	1.97	1.92	1.88	1.85	1.79	1.75	1.68	1.63	1.57	1.51	1.48	1.42	1.39	1.34	1.30	1.28
125	3.92	3.07	2.68	2.44	2.29	2.17	2.08	2.01	1.95	1.90	1.86	1.83	1.77	1.72	1.65	1.60	1.55	1.49	1.45	1.39	1.36	1.31	1.27	1.25
150	3.91	3.06	2.67	2.43	2.27	2.16	2.07	2.00	1.94	1.89	1.85	1.82	1.76	1.71	1.64	1.59	1.54	1.47	1.44	1.37	1.34	1.29	1.25	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	2.05	1.98	1.92	1.87	1.93	1.80	1.74	1.69	1.62	1.57	1.52	1.45	1.42	1.35	1.32	1.26	1.22	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85	1.81	1.78	1.72	1.67	1.60	1.54	1.49	1.42	1.38	1.32	1.28	1.22	1.16	1.13
1000	3.85	3.00	2.61	2.38	2.22	2.10	2.02	1.95	1.89	1.84	1.80	1.76	1.70	1.65	1.58	1.53	1.47	1.41	1.36	1.30	1.26	1.19	1.13	1.08
∞	3.84	2.99	2.60	2.37	2.21	2.09	2.01	1.94	1.88	1.83	1.79	1.75	1.69	1.64	1.57	1.52	1.46	1.40	1.35	1.28	1.24	1.17	1.11	1.00

The $\Sigma\ (\Sigma R)^2/4$ symbolizes the total of the sum of each reactor's total squared divided by the number of items included in the total, in the same way as the column sums and row sums were obtained. As before, C equals $(\Sigma\ x)^2/n$.

Similarly, for other arrangements, the Analysis of Variance provides a tool for separating the variance into the contribution of the separate variables. That is, provided the experiment was planned for such an analysis. The application of a form of analysis to cost estimating problems is presented in Ref. 1.

There are several additional phases of statistics that are of value to the chemical engineer which it is not possible to discuss in the detail they deserve in an article of this length. We will mention these subjects briefly to indicate their scope of application. More information may be obtained from a number of the good texts referred to at the end of this report.

Important Statistical Methods

Quality control, sequential analysis and propagation of error are some additional statistical techniques it will pay you to look at and apply to your engineering problems.

Quality Control

Several good texts are available which deal solely with this subject and it is somewhat presumptious to try to say something about Quality Control in a few lines at the end of an article on Statistics. It is with apologies to my colleagues who have written much in this field that the following is offered.

Quality Control is the application of statistics to

F Values at 0.01 Probabilty Level—Table IX

n_1 = degrees of freedom in mumerator

n_2	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	∞
1	4,052	4,999	5,403	5,625	5,764	5,859	5,928	5,981	6,022	6,056	6,082	6,106	6,142	6,169	6,208	6,234	6,258	6,286	6,302	6,323	6,334	6,352	6,361	6,366
2	98.49	99.00	99.17	99.25	99.30	99.33	99.34	99.36	99.38	99.40	99.41	99.42	99.43	99.44	99.45	99.46	99.47	99.48	99.48	99.49	99.49	99.49	99.50	99.50
3	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.34	27.23	27.13	27.05	26.92	26.83	26.69	26.60	26.50	26.41	26.35	26.27	26.23	26.18	26.14	26.12
4	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.54	14.45	14.37	14.24	14.15	14.02	13.93	13.83	13.74	13.69	13.61	13.57	13.52	13.48	13.46
5	16.26	13.27	12.06	11.39	10.97	10.67	10.45	10.27	10.15	10.05	9.96	9.89	9.77	9.68	9.55	9.47	9.38	9.29	9.24	9.17	9.13	9.07	9.04	9.02
6	13.74	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.79	7.72	7.60	7.52	7.39	7.31	7.23	7.14	7.09	7.02	6.99	6.94	6.90	6.88
7	12.25	9.55	8.45	7.85	7.46	7.19	7.00	6.84	6.71	6.62	6.54	6.47	6.35	6.27	6.15	6.07	5.98	5.90	5.85	5.78	5.75	5.70	5.67	5.65
8	11.26	8.65	7.59	7.01	6.63	6.37	6.19	6.03	5.91	5.82	5.74	5.67	5.56	5.48	5.36	5.28	5.20	5.11	5.06	5.00	4.96	4.91	4.88	4.86
9	10.56	8.02	6.99	6.42	6.06	5.80	5.62	5.47	5.35	5.26	5.18	5.11	5.00	4.92	4.80	4.73	4.64	4.56	4.51	4.45	4.41	4.36	4.33	4.31
10	10.04	7.56	6.55	5.99	5.64	5.39	5.21	5.06	4.95	4.85	4.78	4.71	4.60	4.52	4.41	4.33	4.25	4.17	4.12	4.05	4.01	3.96	3.93	3.91
11	9.65	7.20	6.22	5.67	5.32	5.07	4.88	4.74	4.63	4.54	4.46	4.40	4.29	4.21	4.10	4.02	3.94	3.86	3.80	3.74	3.70	3.66	3.62	3.60
12	9.33	6.93	5.95	5.41	5.06	4.82	4.65	4.50	4.39	4.30	4.22	4.16	4.05	3.98	3.86	3.78	3.70	3.61	3.56	3.49	3.46	3.41	3.38	3.36
13	9.07	6.70	5.74	5.20	4.86	4.62	4.44	4.30	4.19	4.10	4.02	3.96	3.85	3.78	3.67	3.59	3.51	3.42	3.37	3.30	3.27	3.21	3.18	3.16
14	8.86	6.51	5.56	5.03	4.69	4.46	4.28	4.14	4.03	3.94	3.86	3.80	3.70	3.62	3.51	3.43	3.34	3.26	3.21	3.14	3.11	3.06	3.02	3.00
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.73	3.67	3.56	3.48	3.36	3.29	3.20	3.12	3.07	3.00	2.97	2.92	2.89	2.87
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.61	3.55	3.45	3.37	3.25	3.18	3.10	3.01	2.96	2.89	2.86	2.80	2.77	2.75
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68	3.59	3.52	3.45	3.35	3.27	3.16	3.08	3.00	2.92	2.86	2.79	2.76	2.70	2.67	2.65
18	8.28	6.01	5.09	4.58	4.25	4.01	3.85	3.71	3.60	3.51	3.44	3.37	3.27	3.19	3.07	3.00	2.91	2.83	2.78	2.71	2.68	2.62	2.59	2.57
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52	3.43	3.36	3.30	3.19	3.12	3.00	2.92	2.84	2.76	2.70	2.63	2.60	2.54	2.51	2.49
20	8.10	5.85	4.94	4.43	4.10	3.87	3.71	3.56	3.45	3.37	3.30	3.23	3.13	3.05	2.94	2.86	2.77	2.69	2.63	2.56	2.53	2.47	2.44	2.42
21	8.02	5.78	4.87	4.37	4.04	3.81	3.65	3.51	3.40	3.31	3.24	3.17	3.07	2.99	2.88	2.80	2.72	2.63	2.58	2.51	2.47	2.42	2.38	2.36
22	7.94	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26	3.18	3.12	3.02	2.94	2.83	2.75	2.67	2.58	2.53	2.46	2.42	2.37	2.33	2.31
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21	3.14	3.07	2.97	2.89	2.78	2.70	2.62	2.53	2.48	2.41	2.37	2.32	2.28	2.26
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.25	3.17	3.09	3.03	2.93	2.85	2.74	2.66	2.58	2.49	2.44	2.36	2.33	2.27	2.23	2.21
25	7.77	5.57	4.68	4.18	3.86	3.63	3.46	3.32	3.21	3.13	3.05	2.99	2.89	2.81	2.70	2.62	2.54	2.45	2.40	2.32	2.29	2.23	2.19	2.17
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	2.17	3.09	3.02	2.96	2.86	2.77	2.66	2.58	2.50	2.41	2.36	2.28	2.25	2.19	2.15	2.13
27	7.68	5.49	4.60	4.11	3.79	3.56	3.39	3.26	3.14	3.06	2.98	2.93	2.83	2.74	2.63	2.55	2.47	2.38	2.33	2.25	2.21	2.16	2.12	2.10
28	7.64	5.45	4.57	4.07	3.76	3.53	3.36	3.23	3.11	3.03	2.95	2.90	2.80	2.71	2.60	2.52	2.44	2.35	2.30	2.22	2.18	2.13	2.09	2.06
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.08	3.00	2.92	2.87	2.77	2.68	2.57	2.49	2.41	2.32	2.27	2.19	2.15	2.10	2.06	2.03
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.06	2.98	2.90	2.84	2.74	2.66	2.55	2.47	2.38	2.29	2.24	2.16	2.13	2.07	2.03	2.01
31	7.50	5.34	4.46	3.97	3.66	3.42	3.25	3.12	3.01	2.94	2.86	2.80	2.70	2.62	2.51	2.42	2.34	2.25	2.20	2.12	2.08	2.02	1.98	1.96
34	7.44	5.29	4.42	3.93	3.61	3.38	3.21	3.08	2.97	2.89	2.82	2.76	2.66	2.58	2.47	2.38	2.30	2.21	2.15	2.08	2.04	1.98	1.94	191
36	7.39	5.25	4.38	3.89	3.58	3.35	3.18	3.04	2.94	2.86	2.78	2.72	2.62	2.54	2.43	2.35	2.26	2.17	2.12	2.04	2.00	1.94	1.90	1.87
38	7.35	5.21	4.34	3.86	3.54	3.32	3.15	3.02	2.91	2.82	2.75	2.69	2.59	2.51	2.40	2.32	2.22	2.14	2.08	2.00	1.97	1.90	1.86	1.84
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.88	2.80	2.73	2.66	2.56	2.49	2.37	2.29	2.20	2.11	2.05	1.97	1.94	1.88	1.84	1.81
42	7.27	5.15	4.29	3.80	3.49	3.26	3.10	2.96	2.86	2.77	2.70	2.64	2.54	2.46	2.35	2.26	2.17	2.08	2.02	1.94	1.91	1.85	1.80	1.78
44	7.24	5.12	4.26	3.78	3.46	3.24	3.07	2.94	2.84	2.75	2.68	2.62	2.52	2.44	2.32	2.24	2.15	2.06	2.00	1.92	1.88	1.82	1.78	1.75
46	7.21	5.10	4.24	3.76	3.44	3.22	3.05	2.92	2.82	2.73	2.66	2.60	2.50	2.42	2.30	2.22	2.13	2.04	1.98	1.90	1.86	1.80	1.76	1.72
48	7.19	5.08	4.22	3.74	3.42	3.20	3.04	2.90	2.80	2.71	2.64	2.58	2.48	2.40	2.28	2.20	2.11	2.02	1.96	1.88	1.84	1.78	1.73	1.70
50	7.17	5.06	4.20	3.72	3.41	3.18	3.02	2.88	2.78	2.70	2.62	2.56	2.46	2.39	2.26	2.18	2.10	2.00	1.94	1.86	1.82	1.76	1.71	1.68
55	7.12	5.01	4.16	3.68	3.37	3.15	2.98	2.85	2.75	2.66	2.59	2.53	2.43	2.35	2.23	2.15	2.06	1.96	1.90	1.82	1.78	1.71	1.66	1.64
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63	2.56	2.50	2.40	2.32	2.20	2.12	2.03	1.93	1.87	1.79	1.74	1.68	1.63	1.60
65	7.04	4.95	4.10	3.62	3.31	3.09	2.93	2.79	2.70	2.61	2.54	2.47	2.37	2.30	2.18	2.09	2.00	1.90	1.84	1.76	1.71	1.64	1.60	1.56
70	7.01	4.92	4.08	3.60	3.29	3.07	2.91	2.77	2.67	2.59	2.51	2.45	2.35	2.28	2.15	2.07	1.98	1.88	1.82	1.74	1.69	1.62	1.56	1.53
80	6.96	4.88	4.04	3.56	3.25	3.04	2.87	2.74	2.64	2.55	2.48	2.41	2.32	2.24	2.11	2.03	1.94	1.84	1.78	1.70	1.65	1.57	1.52	1.49
100	6.90	4.82	3.98	3.51	3.20	2.99	2.82	2.69	2.59	2.51	2.43	2.36	2.26	2.19	2.06	1.98	1.89	1.79	1.73	1.64	1.59	1.51	1.46	1.43
125	6.84	4.78	3.94	3.47	3.17	2.95	2.79	2.65	2.56	2.47	2.40	2.33	2.23	2.15	2.03	1.94	1.85	1.75	1.68	1.59	1.54	1.46	1.40	1.37
150	6.81	4.75	3.91	3.44	3.14	2.92	2.76	2.62	2.53	2.44	2.37	2.30	2.20	2.12	2.00	1.91	1.83	1.72	1.66	1.56	1.51	1.43	1.37	1.33
200	6.76	4.71	3.88	3.41	3.11	2.90	2.73	2.60	2.50	2.41	2.34	2.28	2.17	2.09	1.97	1.88	1.79	1.69	1.62	1.53	1.48	1.39	1.33	1.28
400	6.70	4.66	3.83	3.36	3.06	2.85	2.69	2.55	2.46	2.37	2.29	2.23	2.12	2.04	1.92	1.84	1.74	1.64	1.57	1.47	1.42	1.32	1.24	1.19
1000	6.66	4.62	3.80	3.34	3.04	2.82	2.66	2.53	2.43	2.34	2.26	2.20	2.09	2.01	1.89	1.81	1.71	1.61	1.54	1.44	1.38	1.28	1.19	1.11
∞	6.64	4.60	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32	2.24	2.18	2.07	1.99	1.87	1.79	1.69	1.59	1.52	1.41	1.36	1.25	1.15	1.00

production or other processes in which quantities of materials are continuously being tested or measured.

Some measurable attribute of the material is used as a criterion of the quality of the product. Random samples are drawn from the production line in succeeding time intervals, and the means of small groups of these samples are compared with some standard. Statistical methods, particularly the *t*-test, provide a method of determining when the measured mean differs from the control value by an amount greater than would be expected by chance.

A typical simple control chart could be developed, for example, for the mean weight of four cartons over a period of sixteen samples. The control could be drawn around a mean of 20 ounces, and control limits drawn at the mean ± two standard deviations, and at the mean ± three standard deviations. These are the values that would be exceeded by chance one time in 20 and one time in 400 if the process were still under control.

Limits are sometimes called the warning limit and action limit respectively. If the 12th sample was outside the "warning" limit, we can expect one in twenty to be outside this limit, and it might just as likely be the first sample in twenty as the twentieth, or the twelfth, so no action is taken, but the process is watched. If the 13th sample was also outside these limits, then some action would be taken, for the process is in trouble.

It might appear at first glance that the actual chart is unnecessary, and that all that need be done is to compare the numerical value of the sample mean with some tabulated control values. However, this tells only part of the story. If means can be expected with equal likelihood to fall on either side of the standard value inside the control limits, then there is less than one chance in a hundred that seven consecutive values will fall on one side of the center line.

Also cyclic effects are more easily picked from a control chart than from tabulated data. For example if one shift, or one day of the week, or one set of machines regularly produced material below or above the standard, this would become evident by periodic cycles in the control chart. The control chart can also indicate a trend tending toward one of the "action" limits before that limit is actually reached. If a series of measurements, eight or ten, are consistently greater than the one before, a definite trend is indicated re-

Who Should Use It?

Statistical methods are of particular importance to design, development, production and research engineers. In fact, they're important to any chemical engineer who has to make decisions based upon collected data.

gardless of whether any limits have actually been crossed.

The central line of the control chart and the limit values may be set either by some arbitrary standards, or from the actual data. The mean of about 25 sets of samples and the pooled estimated standard deviation, calculated by the method outlined in the *t*-test discussion can be used for the initial control lines. As more data are collected, the control lines can be adjusted accordingly.

Also the control chart may be applied to the range of the measured values. Of if the scatter of the data is the important variable, the control chart may be applied to the standard deviation. Standard text on Quality Control, and the A.S.T.M. Manual on Quality Control give examples of the different limits for the range and standard deviation control charts corresponding to the two sigma and three sigma limits for the means.

Sequential Analysis

A powerful statistical tool for acceptance sampling of large scale production was developed during the last war. In fact this method was considered so effective that the original publication[6] was classified Restricted by the U. S. Government.

This method, called Sequential Analysis, permits the making of decisions with respect to accepting or rejecting material with the minimum of sampling. There are a number of different applications of sequential analysis described in the original reference. The example given here is merely intended to show how the method is applied. For application to other specific problems, suitable statistics texts should be consulted.

Suppose we are sampling a production line and want to be 90% certain of not rejecting material that is less than 1% defective, and we want to be 95% certain of not accepting material that is more than 5% defective. Fig. 7 shows the type of control chart used for this example. The cumulative number of defectives is plotted against the total sample. Two inclined lines, set by the tolerance limits and the certainty levels, are drawn on the figure. Crossing the upper line results in rejection of the material, and crossing the lower line results in accepting the material.

When the data lie between the lines, inspection is continued. In the example cited, the equation of the rejection line would be $0.024N + 1.36$, and the equation of the acceptance line would be $0.024N - 1.68$, where N is the cumulative sample size. These lines, and typical data, are shown. With this type of inspection analysis, decisions can be made with the minimum amount of inspection.

Sampling

The subject of sampling has been covered in some detail in Ref. 4. One point which bears emphasis however is the necessity of random samples. By "random" samples, is meant that every item is equally likely to be selected. Samples drawn from the top of a drum of liquid might be higher or lower than the average in impurity depending on whether the impurity was less or greater in density than the bulk of the product. Samples drawn from the top of a drum of granular material, might be lower in fines and hence of a somewhat different composition than the bulk of the solid. Sample taken from the top or bottom of a bed of fluidized solids are often of a different size distribution than the total bed. Samples taken at regular intervals from an around-the-clock operation, are sometimes found to overlook completely the production of one shift.

When the sampling is left to the unconscious subjective judgment of the operator, there is sometimes an overabundance of smoother, better looking, easier to handle items which may not be representative of the total product.

There are many mechanical sampling devices which are used to give a random selection from the batch of material. The "Chemical Engineers' Handbook" discusses a number of these in detail. Another method which is readily applicable when handling data or sampling items that can be enumerated is to make use of a table of random numbers. There are numerous tables of random numbers available in the literature, and there are many ways to use these tables.

If you were testing some material and wanted to inspect one item in a hundred, you could start any place in a table of random digits and take each pair of two digit figures ranging from 00 to 99 and inspect the corresponding item in each group of 100. If you had an experimental program of 25 runs to be made at different conditions, and you wanted to eliminate any possible effect of the order of doing the experiments, you could select again two digit figures from the table of random numbers, discarding those over 25, and ignoring duplicates, and do the experiments in the order in which the numbers 01 to 25 were selected.

An alternative method is to take all the two digit numbers as they occur and divide by 25, leaving remainders from 0 to 24. Calling "0" 25, this will give the 25 random numbers desired, and the process of selecting the random numbers will not be so lengthy as there will be less selections to be discarded.

The use of a table of random numbers in distributing experiments or in selecting samples completely eliminates any subjective factors—or any unrealized cyclic effects that might otherwise creep into an experiment.

Propagation of Error

One last subject of the many in the field of statistics still unmentioned here that is of particular interest to the engineer is the propagation of error. In a simple process in which two streams are measured and combined, if you have estimates of the precisions of the two measurements, what is the precision of the total? In a cost estimate, where the individual

costs of several items are estimated with separate precisions, what is the precision of the total estimate?

There is no rigorous mathematical method of combining the individual precisions, but the variances of the individual measurements may be combined. We have defined the precision, at the 95% confidence level, as approximately twice the standard deviation, which is the square root of the variance. With this relation, we are in a position to find the precision of a combined operation.

The variance of a sum or difference is the sum of the variances. And in general,

$$\text{if } Y = f(x_i)$$

$$\text{the variance of } Y;\ \sigma^2 Y = \sum \left(\frac{\partial f}{\partial x_i}\right)^2 \sigma^2(x_i)$$

Use of this relation is best illustrated by some examples.

If the total W is made up of two streams R, and Q, are known to have precisions of $\pm r$ and $\pm q$ respectively, and if we accept the relation that $r = 2\sigma\ (R)$ and $q = 2\sigma\ (Q)$

$$W = R + Q$$
$$\sigma^2(W) = \sigma^2(R) + \sigma^2(Q)$$
$$W \pm w = R \pm r + Q \pm q$$
$$r = 2\sigma(R);\ q = 2\sigma(Q)$$

$$\sigma^2(W) = \frac{(r)^2}{4} + \frac{(q)^2}{4}$$

$$\sigma(W) = \sqrt{\frac{(r)^2}{4} + \frac{(q)^2}{4}}$$

$$\pm w = 2\sqrt{\frac{(r)^2}{4} + \frac{(q)^2}{4}} = \sqrt{(r)^2 + (q)^2}$$

if $R = 90 \pm 9$
$Q = 10 \pm 1$

$$W = 100 \pm \sqrt{82} = 100 \pm 9.06$$

In this case the precision of the total stream. 100 ± 9.06 is better percentwise than either of the two individual streams. The problem would be solved in the same manner if the stream with the unknown precision was the difference between two measured streams. If the total flow was R and a side stream Q was withdrawn, the residual $W = R - Q$ would have a precision calculated as follows:

$$\sigma^2(W) = \sigma^2(R) + \sigma^2(Q)$$

$$\sigma^2(W) = \frac{(r)^2}{4} + \frac{(q)^2}{4}$$ where r and q are the precisions on R and Q respectively

and $\pm w = \sqrt{(r)^2 + (q)^2}$

if $R = 90 \pm 9$
$Q = 10 \pm 1$

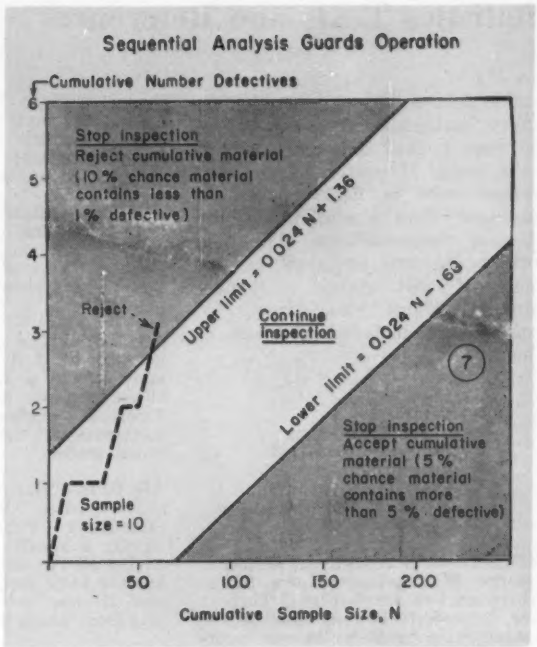
$$W = 80 \pm \sqrt{82} = 80 \pm 9.06$$

In this case the precision of the residual, 80 ± 9.06 is poorer percentwise than either of the two measured streams.

As an example of the more involved formula for the variance of a function made up of several measurements, consider a total flow W made up of two streams as before R and Q with individual precisions $\pm r$ and $\pm q$ respectively, and each stream containing a component C in concentrations A and B and that these concentrations are known with precisions $\pm a$ and $\pm b$.

The total flow of C is then

$$C = RA + QB$$



and the question is how well do we know the value of C.

The variance of C is related to the variances of the four quantities according to the equation for the variance of a function as follows:

$$\sigma^2(C) = R^2\sigma^2(A) + A^2\sigma^2(R) + Q^2\sigma^2(B) + B^2\sigma^2(Q).$$

If we set numerical values for the various quantities

$R = 90$ $\quad Q = 10$ $\quad r = \pm 9$ $\quad q = \pm 1$
$A = 0.10$ $\quad B = 0.20$ $\quad a = \pm 0.01$ $\quad b = \pm 0.02$

$$\sigma^2(R) = \left(\frac{r}{2}\right)^2 \qquad \sigma^2(Q) = \left(\frac{q}{2}\right)^2$$

$$\sigma^2(A) = \left(\frac{a}{2}\right)^2 \qquad \sigma^2(B) = \left(\frac{b}{2}\right)^2$$

$$\sigma^2(C) = \left(\frac{0.9}{2}\right)^2 + \left(\frac{0.9}{2}\right)^2 + \left(\frac{0.2}{2}\right)^2 + \left(\frac{0.2}{2}\right)^2$$

$$\pm C = 2\sigma(C) = \sqrt{(0.9)^2 + (0.9)^2 + (0.2)^2 + (0.2)^2}$$
$$= \sqrt{1.70} = \pm 1.30$$
$$C = 11.0 \pm 1.3$$

The only limitation on this type of propagation of error is that the quantities involved must be independent so that changes in the levels of one do not affect the variance of others.

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Statistics Texts and References

The following books range from heavy mathematical presentations to "cook books." The arrangement is in order of preference of your author—who is first a chemical engineer, then a statistician and then a mathematician. The bold letters indicate coverage of the topics of most interest to the engineer. (Many other items, of course, are included in most of the texts.)

A—t test
B—X^2 test
C—Linear Correlation
D—Multiple Correlation
E—Curvilinear Correlation
F—Analysis of Variance
G—Design of Experiments
H—Quality Control

ABCDEF — "Statistical Methods," George W. Snedecor (Iowa State). There are two drawbacks to this text: one, it needs to be read consecutively inasmuch as problems in one section refer to solutions worked out earlier; and two, the problems are all from agriculture. However, it is the best single text from which first to learn statistics.

ABCF—"Introduction to Statistical Analysis," Dixon and Massey (Mcgraw-Hill). This is a good text for the engineer for the subjects indicated. There are also other valuable sections on sequential analysis and nonparametric statistics.

ABCDEFGH—"Methods of Statistical Analysis," Cyril H. Goulden (Wiley). This complete text will be easily understood by engineers, and is recommended for self study.

ABCDEFH—"Statistical Methods in Research and Production," Edited by Owen L. Davies (Hafner Publishing Co.). A very good preliminary text, covering well the items indicated. It is a British publication and the American Engineer may find some of the presentation a little stilted. The nomenclature varies slightly from American usage.

ABCDE—"Fundamentals of Statistics," Truman Lee Kelley (Harvard). This large text, 750 pages, completely covers the field (including a test by which students may check whether their mathematical background is adequate).

ABCF—"Facts from Figures," M. J. Moroney (Pelican). This little pocket book is very good reading. While it is not a text in the ordinary sense, it has problems which it would pay an engineer to understand. Again it is British and may offer slight nomenclature difficulties.

ABC—"Elements of Statistics," H. C. Fryer (Wiley). This is a good introductory text for the engineer; perhaps a little too elementary. It contains nothing about analysis of variance or multiple correlations.

ABCDFG—"Statistical Analysis in Chemistry and the Chemical Industry," Bennett and Franklin (Wiley). This is a complete text which the engineer should be able to study with profit.

ABCDEF—"The Methods of Statistics," L. H. C. Tippett (Wiley). Another text by a British author which although good, may be difficult for American engineers. It is more mathematical than most engineers would prefer.

ABCDFH—"Handbook of Probability and Statistics," Burlington and May (Handbook Publishers). This is strictly a handbook. It is useful for having all the tables in one place and has the basic formulas which may be used if once understood. It is not a text from which to learn statistics.

ACFG — "Statistical Methods for Chemists," W. J. Youden (Wiley). While this book deals with some of the elementary statistical concepts, it is not an introductory text. It appears to be intended to discuss with the chemist the application of statistics rather than to teach it. It makes very interesting reading after the elements have been mastered.

ABCDFGH — "Industrial Experimentation," K. A. Brownlee (Chemical Publishing). While this is strictly a "cook book", the engineer would do well to know all the recipes in it. The price of the American edition is too high, but the British edition for about a quarter of the price gives about the best buy for a statistics text. You won't learn statistics from it, but you will learn how to use statistics.

ABCDEFG — "Statistical Theory in Research," Anderson and Bancroft (McGraw-Hill). An engineer who remembered his differential and integral calculus would be able to work through this text—advanced calculus would help. It is a good text for a hard year's work and it will repay the engineer who masters it.

ABCDF—"Introduction to Mathematical Statistics," Paul G. Hoel (Wiley). A good text but probably too mathematical for most engineers.

ABCF—"Statistical Methods for Research Workers," R. A. Fisher (Oliver & Boyd, London). This is the bible of statisticians and belongs in the library of all practicing members. Much can be learned from it, but most engineers will find other American texts more useful.

ABCDEFH—"Statistical Theory with Engineering Applications," A. Hold (Wiley). A complete mathematical presentation which might make this good text too much for the engineer.

ABCEF — "Elements of Statistics," Elmer B. Mode (Prentice-Hall). Engineers will find this a good text for an introduction to statistics. The section on analysis of variance is very limited, and perhaps too much text is devoted to charts and diagrams.

G—"Design and Analysis of Industrial Experiments," Edited by Owen L. Davies (Hafner Publishing Co.). A companion book to "Statistical Methods in Research" but much more formidable. It could serve as a text for a full year's course in Design of Experiments, and short of thorough study, will not avail much to an engineer. It is worth thorough study, however, for anyone interested.

CED — "Statistical Adjustment of Data," W. Edwards Deming (Wiley). This text provides solution to more involved correlations, but a more elementary statistical text should be mastered first.

H—"Statistical Quality Control," E. L. Grant (McGraw-Hill). An easy and essential book for the engineer dealing with quality control problems.

H—"Quality Control Handbook," J. M. Juran (McGraw-Hill). A collection of contributions dealing with actual quality control problems. After "Grant", this is a second must for quality control engineers.

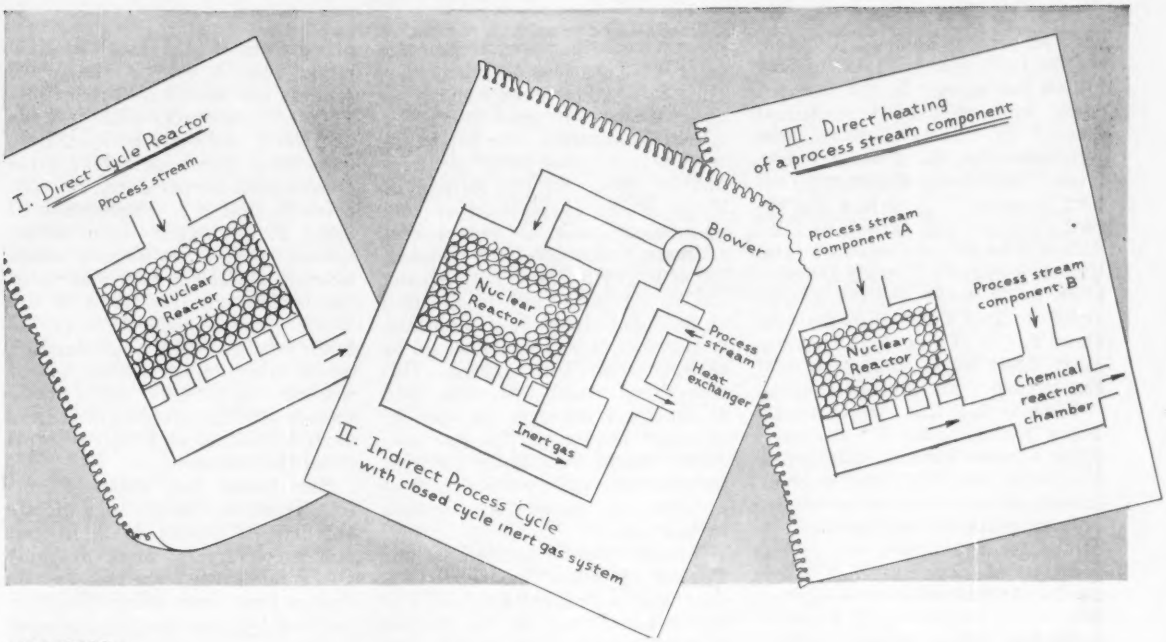
H—"Engineering Statistics and Quality Control," Irving W. Burr (McGraw-Hill). Despite the title, this book deals almost exclusively with quality control.

H — "Manual on Quality Control," (ASTM). This manual will be useful and almost essential for the engineer dealing with quality control.

GH—"Design and Analysis of Experiments," Oscar Kempthorne (Wiley). This text deals almost entirely with design of experiments and for that purpose is quite good. A strong foundation in mathematics is not necessary.

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COMING:

Process Heat from Nuclear Reactors

For high temperature reactions like these . . .

Coal + Steam + Oxygen —(2,500 F.)→ Synthesis gas

Hydrocarbons —(2,600 F.)→ Acetylene

Methane + Ammonia —(2,200 F.)→ Hydrocyanic Acid

. . . see what fission heat can do

RICHARD H. GRAHAM, U. S. Atomic Energy Commission

Design and process engineers shouldn't pass up fission heat as a possible energy source for their high-temperature reactions.

Today most rapid expansions in the nuclear field are in the production of electrical energy. But since existing nuclear systems involving the steam cycle (with its inherent limitations) are inefficient, other application techniques must be studied. And the outlook for economic utilization of fission energy in all fields will improve with progress in reactor technology and lower costs of fissionable material.

Importantly, trends of increased cost of fuel gases and residual fossil fuels indicate that fission heat will become competitive for direct application to chemical process industries—possibly within the next decade. Because of differences in temperature requirements, this development won't be tied to the advent of economic nuclear electrical power generation. And it will have this advantage: Heat can be supplied directly into the process stream with minimum losses, though some minimal or short-lived contamination of processed material might occur because of nuclear activation.

On the basis of cost per unit of total energy available in fuel delivered to the plant site, coal, gas, oil and fission fuel are cheap compared with electrical energy. If we consider the efficiency of applying this heat to the process stream and balance stack losses of conventional boilers against immersion heating techniques possible with nuclear reactor fuel elements, coal, gas and oil become more expensive than fission fuel. Thus, the financial return for improved use of fission fuel should be high.

This change to a new major fuel source seems consistent with past U. S. experience. Until 1887 wood was the major source; from 1887 to 1938 coal dominated; since 1949 fluid fuels have supplied over 50% of the total national energy requirement.[1]

Needed and Coming

In 1947, 11.2% of the total national energy consumption was

used as process heat. U. S. industry, in 1953, spent a total of $5.4 billion for energy in the form of fuels and purchased electrical power.[3] Of this total, 72.4% was purchased by the process industries. Considering the Putnam report[4] forecast, this is how the hypothetical energy system of 2050 A.D. will be distributed: 15% total income energy (solar, wind, hydro, etc.), 85% total capital energy (60% nuclear fuels, 25% residual fossil fuel). It's obvious that nuclear fuels must soon take over the burden from present sources.

Nuclear fuel has certain advantages which make it attractive from a plant location standpoint. For sites far from fuel sources, transportation charges for fissionable material are negligible. This allows for a plant site at a remote location of raw materials where product transportation costs are low.

Another plant location advantage may lie in proximity to the market of a product with high shipping costs. If this market is also far from conventional fuel sources and the process has large heat requirements, fission heat can compete if raw material transportation costs don't interfere.

These Could Use It

Here are a number of processes which could take advantage of nuclear process heat:

- Coal gasification.
- Wisconsin nitrogen process.
- Wulff process acetylene.
- Salt water conversion.
- Hydrocyanic acid.



RICHARD H. GRAHAM has been concerned with nuclear reactor design problems since 1948. In 1954 he joined the AEC's division of reactor development and is currently responsible for an experimental program on reactor safety.

Coal Gasification—An important process now under joint investigation by AEC and the Bureau of Mines is the gasification of coal by nuclear heat. A recent cost estimate, based on a cost comparison of U_{235} ($15/gram) with oxygen ($5/ton), shows that gasification of coal and steam in a high-temperature nuclear reactor would be cheaper than with oxygen. Gas cost drops about 6% with each $5-per-gram decrease in cost of enriched uranium. The gas produced would eventually be used for synthetic fuel production or as a hydrogen source for ammonia production.

A pilot plant operated by the Bureau of Mines[5] gasified 84.5% coal with an oxygen-coal ratio of 8.75 standard cu. ft. per lb. and a steam-coal ratio of 0.40 lb. per lb. Oxygen and steam were superheated to 1,000 F.; reaction chamber temperatures approached 2,500 F. Nuclear reactor techniques can most probably be adapted to this process.

Nitrogen Fixation — Another possible process is the Daniels' Wisconsin process[6] for nitrogen fixation in which air could be heated in a nuclear-fueled pebble bed. Now a regenerative furnace heats air to 2,100 C. and cools at the rate of 20,000 deg./sec. to a temperature of 1,500 C. Under these conditions, about 2% of the effluent gas stream appears as nitrogen dioxide.

A natural gas fueled demonstration plant was successfully run at the Sunflower Ordnance plant in Kansas at a production rate of 40 tons/day of NO_2. The furnace ran up to maximum temperatures of 4,240 F.; 3,700 F. was considered a reasonable level for long furnace life. The operating factor of the furnace was extremely high—about 90%. The plant has now been placed on standby because of high costs resulting from an elaborate NO_x recovery system (silica gel absorption).

A switch to nuclear heat wouldn't eliminate this cost problem; it must be solved by other techniques. Nuclear fuel advantage must be weighed against plant site fuel costs.

Acetylene—Another pebble bed process in which nuclear fuel might play a role is the Wulff process for acetylene production. This involves cracking natural gas at 2,600 F., followed by immediate quenching. Since acetylene yield climbs with temperature, it's conceivable that if a temperature of 3,000 F. or higher could be attained, process economics would improve. And since two-thirds of the natural gas consumed in the Wulff process is used for pebble bed heating, gas consumption would also improve with use of nuclear fuel. But still to be answered is the problem of tar and carbon residues and their removal from the reactor.

Salt Water Conversion—Favorable economics might also dictate the use of fission fuels in salt water conversion. Most probably this would involve the use of waste fission heat from other processes.

The minimum theoretical energy needed to convert salt water to fresh is 900 kwh. per acre-ft. with a practical lower limit of 8,000 kwh.[8] Reasonable economics show that $125 can be spent in recovering an acre-ft. of sea water or $40 per acre-ft. of brackish water. At a cost of 10 mills/kwh. for nuclear electricity, sea water could be recovered at $80 per acre-ft. if the 8,000 kwh. lower limit is reached in salt water process systems. This may be valuable on arid coasts where other power isn't available.

Hydrocyanic Acid—HCN Production from methane and ammonia could also be economically attractive. At high temperatures, the reaction might proceed without a catalyst. At lower temperatures, when a catalyst is used, an intense neutron field would poison the catalyst by forming new elements. Recovery and recycling of an expensive catalyst can be complicated by induced radioactivity.

Process steam from nuclear fuels can be attractive to industries like pulp and paper, particularly in areas where conventional fuel costs are unusually high.[9]

What the Reactor Looks Like

Let's consider the current conceptual design of a process heat reactor. High temperature requirements dictate the use of ceramics in construction. There-

fore, the reactor bed could consist of ceramic fuel elements, each with a core of uranium oxide. These elements may be either spheres or rectangles.

The reactor's neutron spectrum will likely be thermal in character, for low power density. The fuel element could be a silicon, beryllium or zirconium carbide shell coating a matrix of the same material impregnated with U_{235}-enriched uranium oxide. Control rods are boron-based ceramics. If the carbide in the fuel elements doesn't provide sufficient moderation, additional moderator and reflector materials—carbides or oxides of beryllium or zirconium—could be used.

Although a rigid core has been proposed, other considerations (e.g., plugging and heat removal) might make a fluidized bed core more desirable.

Problems to be Licked

Of course, getting process heat from a nuclear reactor will raise many problems, such as:

- Erosion—due to solid particle motion in the process stream.
- Thermal shock to ceramic fuel elements.
- Fission product diffusion through ceramic walls.
- Channeling and packing of solids—either those entering or those formed during process reactions.
- Coolant flow plugging and thermal hot spots—resulting from solids deposited in the reactor.
- Control rod entries through a high-temperature shell and mechanical operation at these temperatures.
- Reflector-type control.

Solutions to some, but not all of these, have been proposed. Thermal shock could be minimized if conservative temperature rates of change are specified in operating practice. If ceramics don't provide adequate containment to eliminate fission product diffusion, an impervious high-temperature jacketing material might work.

By designing the reactor core for optimum moderation, no radiation hot spots (resulting from carbon deposits) will occur. And any thermal hot spots which might result from restricted heat removal can be removed by agitating or backflushing the core. If the reactor deposit is non-carbonaceous and low melting, hot spots can be eliminated by simply melting the deposit.

Unless reactor walls are thin, reflector-type control (i.e., removing part of the reactor core reflector or control by introducing nuclear poisons next to the core periphery) will be impossible. This precludes the use of thick refractory walls. But one way to get around this is to use metallic shells protected by film-cooling techniques. A water-cooled vessel would allow for introduction of enough agitation to the neutron flux to control the reactor.

Addition of inert gases (e.g., BF_3) with negative nuclear characteristics to the feed stream can be helpful. But it must be supplemented, since reactor shutdown can't be guaranteed if the feed stream fails. The velocity of the feed material stream could be used to control the reactor's power generation rate. The power level can be adjusted to the process stream demand by making the position of a poison rod or fuel rod sealed in the reactor proportional to the gas velocity through the core. Some large volume process streams with materials of high nuclear activation can't be handled with this proposed fuel since sufficient holdup potential to allow decay of radioactive contamination would be very expensive.

Except for several mechanisms—e.g., increased number of cross-linked bonds in irradiated polyethylene—effects of radiation on accelerating or retarding specific chemical reactions is unknown. These effects may be beneficial or detrimental to the application of fission heat to the process industries. Radiation effects aren't expected to be very important. The need for using fission fuels will depend primarily on costs per unit of heat of the various fuels.

More Than Speculation

An atomic reactor for production of synthesis gas is on its way to becoming a reality, now that AEC and the Bureau of Mines have formally agreed to go ahead with conceptual design work.

Present plans call for 6 months to a year on design, 1½ to 2 years to solve materials problems—construction materials for a reactor that could withstand the 2,500 F. or higher heat generated, uranium fuel elements to withstand high heats, heat transfer materials. Assuming that no difficulties are encountered, the reactor could be built and probably put into operation some time in 1959.

Looking Ahead

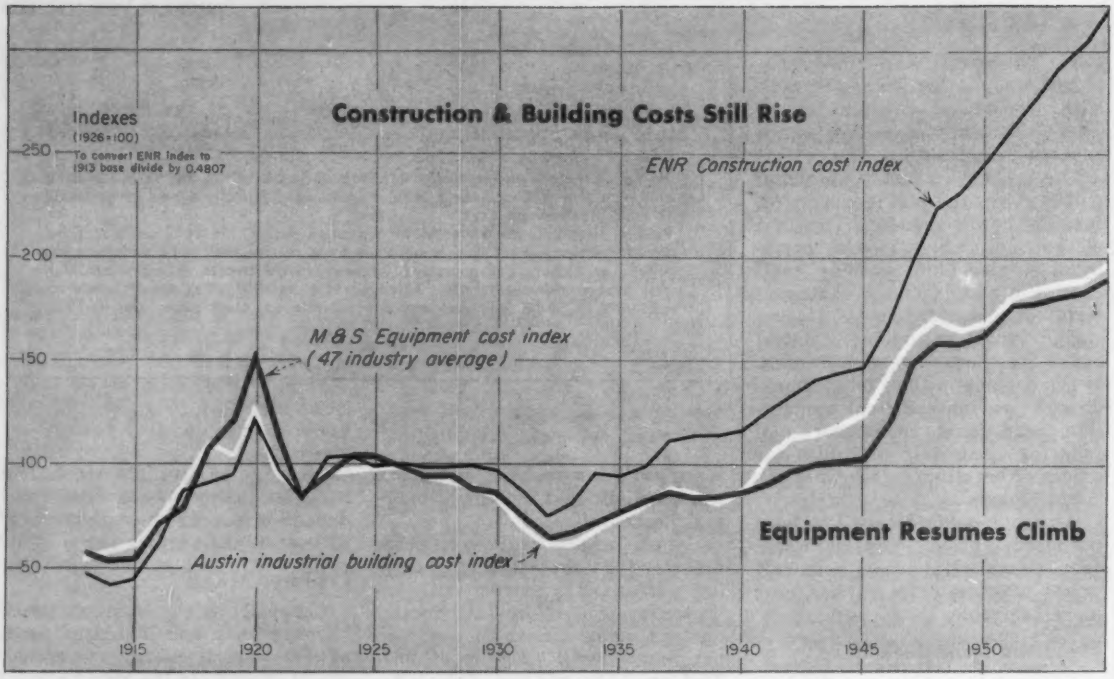
Considering the current population growth and increased rates of per capita energy consumed, major changes in the world energy balance will be mandatory. And it seems certain that fission fuels must be used to meet the world's increasing energy requirements.

Nuclear fuel must be added to the energy pool and used as efficiently as possible. If fissionable material can be used at better than 50% effectiveness in process heat applications, the energy pool will be less rapidly depleted.

Use of income energy sources (solar radiation, wind power, etc.) and capital energy sources must be balanced to best serve the world energy requirements while conserving those things which have uses as other than energy sources. (Fossil fuels, for example, are becoming too valuable as stepping stones to more sophisticated organic materials to permit their use as heat sources.) Early application of the fission reaction to process heat will be valuable in accomplishing this balance.

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4. "Wisconsin Nitrogen Process," *C&EN*, p. 2372 (1955).
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No Letup in Equipment Cost Rise

Tabulated below are the annual average indexes of comparative equipment cost for eight process industries and four related industries, prepared by the evaluation engineering firm of Marshall and Stevens, incorporated of Illinois, Chicago 4. Extending from 1913 through 1955, the annual averages are supplemented by the quarterly figures on the individual charts at the right.

A tabulation each month in the Process Equipment News section, shows latest revisions for the quarters ending March, June, September and December.

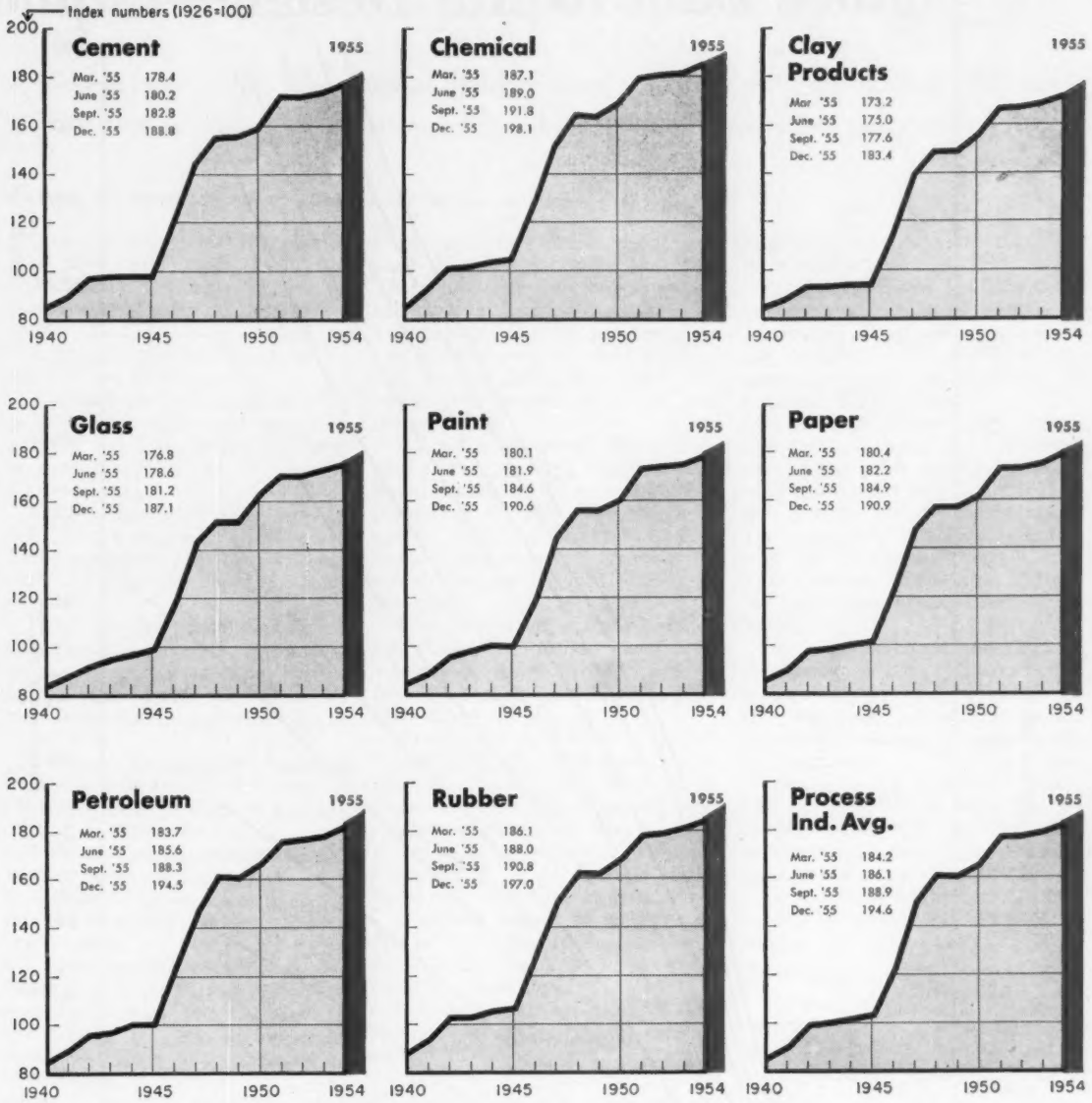
This feature was introduced initially on pages 124-6 of our November 1947 issue, in an article by the late R. W. Stevens, partner of the firm, which described the basis for the 47 industry indexes regularly issued by the firm, and the method of weighting the process industry average.

Charted above is the M & S 47-industry average plotted on the same grid with the Austin Co's index of industrial building costs, and the Engineering News-Record index of heavy construction costs.

All process industry components of the M & S index rose steadily during each quarter of 1955 forcing yearly averages to new highs.

Marshall and Stevens Annual Indexes of Comparative Equipment Costs, 1913 to 1955 (1926 = 100)

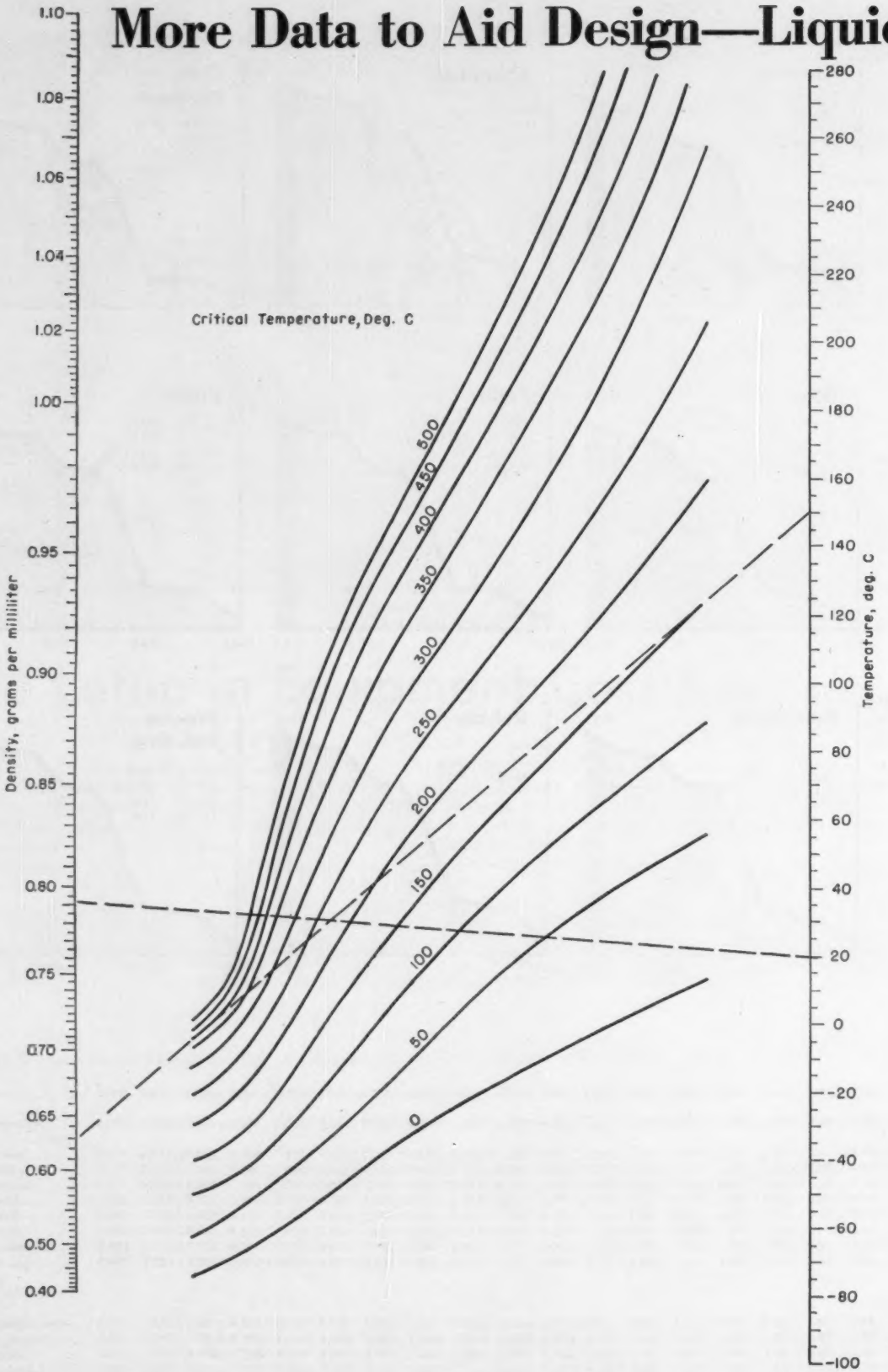
Industry	1913	1916	1918	1920	1922	1924	1926	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Average of all	57.9	62.8	109.7	153.3	85.5	105.3	100.0	96.5	91.9	87.0	76.9	66.1	69.4	74.6	78.0	81.6	88.3
Process Industries																	
Cement mfg	58.0	62.5	109.1	149.2	83.7	104.6	100.0	97.2	92.5	87.0	76.8	68.9	70.7	75.7	78.1	82.2	88.8
Chemical	59.0	63.0	111.9	150.5	82.5	105.6	100.0	96.9	92.4	82.0	78.0	77.6	70.9	75.4	78.5	82.5	88.2
Clay products	60.7	65.3	120.0	154.3	82.9	105.7	100.0	97.0	91.7	86.1	78.0	70.6	71.1	75.7	79.3	83.2	87.8
Glass mfg	58.7	63.5	112.1	151.1	83.7	101.9	100.0	95.9	92.1	86.6	77.9	69.4	71.2	75.4	78.5	82.6	88.0
Paint mfg	58.2	62.8	108.0	148.5	84.1	104.0	100.0	94.6	91.7	85.7	76.6	71.7	70.1	74.6	77.2	81.5	87.4
Paper mfg	60.4	63.4	111.8	152.6	83.1	105.6	100.0	96.8	90.9	86.5	77.1	67.2	69.9	75.4	78.5	82.7	83.1
Petroleum Ind	58.9	64.1	113.0	151.5	82.7	106.0	100.0	97.1	92.0	86.2	77.6	70.1	70.6	76.0	78.7	82.6	87.8
Rubber Ind	58.6	63.8	113.8	154.2	88.0	105.9	100.0	91.9	91.9	86.2	77.0	67.1	70.7	75.2	78.1	82.2	88.4
Related Industries																	
Elec. power equip	59.1	64.3	114.2	152.2	83.6	106.0	100.0	96.9	91.8	86.1	78.1	70.1	70.7	75.5	78.7	82.7	87.9
Mining, milling	56.8	62.9	111.9	149.9	82.8	105.6	100.0	97.2	92.9	86.7	76.8	67.6	80.0	85.6	88.5	92.4	97.1
Refrigerating	59.3	63.2	113.5	153.5	83.9	96.1	100.0	97.0	92.0	86.4	75.0	70.0	71.3	75.4	78.9	83.0	87.5
Steam power	59.1	64.3	114.2	152.2	82.7	106.1	100.0	96.9	91.8	86.2	88.1	70.1	70.7	75.5	78.7	82.7	87.0



1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	
84.4	84.8	86.6	92.6	99.6	100.5	102.4	103.4	123.2	150.6	162.8	161.2	167.9	180.2	180.5	182.5	184.6	190.6	.....Average of all
85.2	84.6	85.4	90.8	97.8	98.3	98.6	99.4	119.7	144.3	156.5	156.6	161.6	172.7	172.8	174.6	177.6	182.6	.....Cement mfg.
84.4	83.8	84.6	93.3	102.0	103.1	105.6	106.5	126.8	151.5	164.5	164.5	169.6	180.7	181.1	183.1	186.3	191.5	.....Chemical
83.2	82.7	83.7	87.6	93.1	93.6	93.9	94.8	115.0	139.8	151.5	151.5	156.6	167.7	167.7	169.5	172.4	177.3	.....Clay products
83.4	83.0	84.3	88.2	93.7	94.7	96.5	97.4	117.6	142.3	154.6	154.6	159.7	170.8	171.0	173.0	176.0	180.9	.....Glass mfg.
83.9	83.9	84.9	90.3	97.3	98.3	100.1	101.0	121.2	146.0	157.8	157.8	162.9	174.0	174.4	176.3	179.3	184.3	.....Paint mfg.
84.8	84.1	85.1	90.5	97.5	98.7	101.3	102.2	122.4	147.0	158.1	158.1	163.2	174.3	174.7	176.6	179.5	184.6	.....Paper mfg.
83.3	82.3	82.8	88.2	95.2	96.7	100.0	100.9	121.6	147.2	160.9	160.9	166.0	177.1	177.6	179.7	182.8	188.0	.....Petroleum ind.
85.4	85.3	86.3	94.2	102.7	103.7	105.5	106.4	126.6	151.2	163.3	163.3	168.4	179.5	180.0	182.1	185.2	190.5	.....Rubber

84.3	84.1	85.8	90.5	96.5	97.5	99.3	100.2	122.9	150.0	166.1	166.1	171.2	182.3	182.8	184.9	188.1	193.3	...Elec. power equip.
92.6	92.1	93.1	98.5	105.5	106.2	107.3	108.2	128.4	153.0	165.2	165.2	170.8	181.4	181.9	184.1	187.2	192.6	.....Mining, milling
83.0	82.1	83.1	89.0	95.8	97.0	100.1	101.7	125.7	162.2	176.7	175.8	185.2	200.1	200.7	202.8	204.9	211.6	.....Refrigerating
82.2	81.7	82.7	86.6	92.1	92.8	93.9	94.8	116.0	141.7	153.2	153.2	158.5	169.9	170.5	172.6	175.7	180.4	.....Steam power

More Data to Aid Design—Liquid



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Nomograph helps you convert density data available at room temperature to densities at higher temperatures. Extends usefulness of common data many fold.

JAMES O. OSBURN, State University of Iowa, Iowa City

DID you ever wish your handbook were more complete? Chances are you have, if you've ever tried to calculate a friction factor, heat transfer coefficient, tank volume, plate efficiency, or allowable flow rate.

You need liquid density for each of these. Yet only for a very few common materials do you find data in your handbook at the higher temperatures.

Lange's handbook[4] has density data over a range of temperature for 68 substances; the International Critical Tables[7] list about 300 compounds.

What can the designer do when data cannot be found? A solution to the designer's problem lies in correlations. Let's see what we have to work with, and what we can do with it.

When you use physical properties in design calculations it is best to have experimental data. If you are making a final plant design, you will want to get experimental data. But for other calculations, the next best thing is an equation or a correlation by which you can calculate the property.

A good example of a useful correlation is the ideal gas law. This equation enables you to calculate the density of a gas at moderate pressures. Then with generalized compressibility chart you can estimate closely the corrections for high pressure. Because of this, tables of gas density at various temperatures and pressures ordinarily are not needed.

A similar law has not been established for liquids. The best we can do is to take some readily available data and expand them to suit our purposes. A new and convenient nomograph is shown for doing this with liquid density. If you know the density at one temperature as well as the critical temperature, this nomograph will give you the density at other temperatures.

Previous Methods

To get the background for this nomograph we can look at some other methods which have been used to solve the same problem. There are four different types of correlations used for calculating or extrapolating liquid density. For two of these you can start without any density data; the other two require the density at one or two temperatures.

Atomic Volumes—By the method of LeBas,[5] you can calculate the liquid density at the normal boiling point from the molecular structure alone. An explanation of this method and a complete table of atomic volumes is given in Perry's handbook.[8]

The following example shows how this method works. The atomic volumes of three elements are as follows: carbon—14.8, hydrogen—3.7, sulfur—25.6.

To calculate the density of methyl sulfide, $(CH_3)_2S$, at its normal boiling point, we add the contributions from each atom. Thus, the volumes comprising total mole volume are: 2 carbon atoms—29.6; 6 hydrogen atoms—22.2; 1 sulfur atom—25.6. Total mole volume is 77.4.

Molecular weight of methyl sulfide is 62.13. Density is, therefore, 62.13/77.4 or 0.803. Observed density is 0.831.

This method is very helpful when you don't have any density data at all, and it usually gives fairly good results. A big disadvantage—it gives density at only one temperature, the normal boiling point.

Correlate by Class—Densities of hydrocarbon liquids have been studied extensively. Equations and methods of calculating the densities of these substances to a high degree of accuracy are given by Kurtz and Sankin,[9] and by Brown, Katz, Oberfell and Alden.[1] Hammond and Lundberg[2] have done the same for fatty acid esters.

Similar equations probably could be developed for other classes of compounds. Eventually, you may be able to calculate the density of any compound, just by knowing its chemical classification.

Expansion Factor—The expansion factor correlation of Watson[10] can be used for any pure liquid when you know critical data and the density at one temperature. The expansion factor, ω, depends only on the reduced temperature and pressure. Expansion factors for liquids are shown in the table below.

For a given liquid, the ratio of the density to the expansion factor is constant, or $\rho_1/\omega_1 = \rho_2/\omega_2$. In this equation, ρ_1, is the known density at a standard temperature and pressure. At the same conditions ω_1 is the expansion factor. You can find, in the table, the expansion factor for another temperature and pressure and calculate the corresponding density.

To illustrate, let us calculate the density of methyl sulfide at 150 C. and 16 atm. Data are:

Critical temperature T_c = 229.9 C. or 503.0 K.

Critical pressure p_c = 54.6 atm.
Density, 37 C., 1 atm. ρ_1 = 0.831

At condition 1, where the density is known,

$T_R = T/T_c = (37.0 + 273.1)/(503.0) = 0.617$

$p_R = p/p_c = (1)/(54.6) = 0.0183$

Interpolating from Table 1, $\omega_1 = 0.123$

At 150 C. and 16 atm.,

$T_R = (150.0 + 273.1)/(503.0) = 0.841$
$p_R = (16)/(54.6) = 0.293$
$\omega^2 = 0.099$

Values of the Expansion Factor[10]—Table I

	Expansion Factor ω							
T_R	$P_R = 0$	$P_R = 0.4$	$P_R = 0.8$	$P_R = 1.0$	$P_R = 1.5$	$P_R = 2.0$	$P_R = 3.0$	$P_R = 5.0$
0.5	(0.1328)	.....	.....	0.1332	.....	0.1338	.....	0.1350
0.6	0.1242	.....	.....	0.1250	.....	0.1258	.....	0.1275
0.7	0.1144	0.1150	.....	0.1158	.....	0.1170	0.1182	0.1202
0.8	0.1028	0.1042	0.1050	0.1056	0.1070	0.1077	0.1098	0.1125
0.9	.....	0.0900	0.0915	0.0926	0.0949	0.0968	0.1002	0.1043
0.95	.....	.....	0.0810	0.0831	0.0872	0.0902	0.0943	0.1000
1.0	.....	.....	.....	0.0440	0.0764	0.0818	0.0875	0.0954

Calculation of Critical Temperature[6]—Table II

T_c = critical temperature, deg. K.
T_b = normal boiling point, deg. K.

For compounds boiling below 235 K. and for all elements:

$$T_C = 1.70\ T_b - 2.0$$

For compounds boiling above 235 K.:

Compounds containing halogens or sulfur:

$$T_c = 1.41\ T_b + 66 - 11\ F$$

Aromatic compounds and naphthenes (halogen- and sulfur-free):

$$T_c = 1.41\ T_b + 66 - r\ (0.383\ T_b - 93)$$

Other compounds:

$$T_c = 1.027\ T_b + 159$$

Note: F = number of fluorine atoms in the molecule.
r = ratio of non-cyclic carbon atoms to total number of carbon atoms in the compound.

Then, $\rho_2 = (\omega_2/\omega_1)\ (\rho_1) = (0.099)/(0.123)\ (0.831) = 0.669$. The experimental value[7] is 0.671.

If the critical constants are known or can be estimated, and the density at one temperature is known, you can use this method to give results reliable to 5% in most cases. It automatically adjusts for the change in density due to liquid compressibility.

The only criticism is that the method is somewhat tedious. It could be improved by putting the correlation in a form so that the density could be read directly.

Othmer Chart—Othmer, Josefowitz and Schmutzler[9] developed a nomograph for liquid density. Density at any temperature is read directly from this chart, with the aid of a characteristic point for each substance. Coordinates for characteristic points of 65 substances are given in the article.

This is only a minute fraction of the number of liquids which may be encountered. You can use the nomograph for substances not listed if you know the density of the liquid at two different temperatures. In most cases, however, the density is not known for two temperatures.

New Correlation

Returning to nomograph, this chart is as easy to use as the Othmer chart, easier than the other correlations. It differs from the Othmer chart in the method of locating the point for a new substance. Only the critical temperature and the density at one temperature are needed.

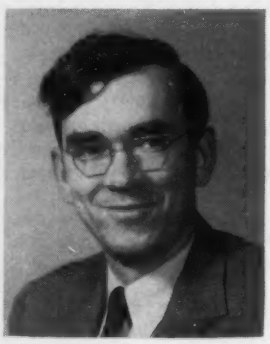
For many liquids handbooks give the normal boiling point and the density at room temperature. If not available, these two properties are relatively easy to measure.

Critical temperature can be calculated from the normal boiling point and the chemical structure. Thus, the new correlation uses readily available information.

Developing Chart—Nomograph was made by first laying off a linear temperature scale. Density scale was calibrated with the aid of density data on four reference substances taken from the Critical Tables. These were ethane, 0.40-0.55; benzene, 0.55-0.80; acetic acid, 0.80-0.93; carbon tetrachloride, 0.93-1.1.

A point to represent ethane was placed on the nomograph in an arbitrarily selected position. Location of this position affects calibration of the density scale and the range of values covered. Othmer's nomograph was used as a guide.

Points were located for other liquids for which density-temperature data were available. Each point was labeled with the critical temperature of the corresponding substance. Lines of constant critical temperature were evident and they were drawn.



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Estimate Critical Temperature—If the critical temperature and the density at one temperature are known, nomograph can be used to estimate the density at another temperature. However, the critical points of only a few substances are known.

To overcome this difficulty, the equations of Meissner and Redding[6] are helpful. These predict critical temperature from the structure and normal boiling point. Table II lists the equations.

How to Use Chart

To illustrate the use of nomograph, we shall calculate the density of methanol at 150 C. These data are available: density at 20 C.—0.792; normal boiling point—64.7 C.

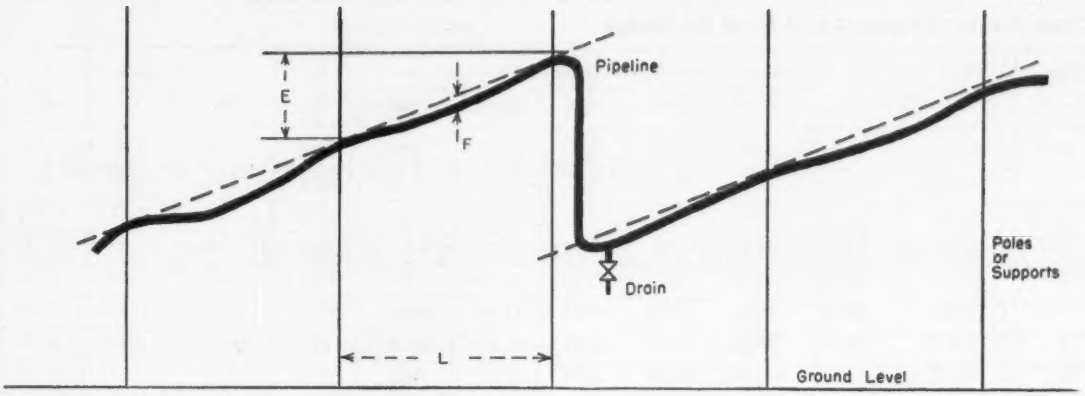
First, estimate the critical temperature from the boiling point. $T_c = (1.027)\ (64.7 + 273.1) + 159 = 506$ K., or 233 C. (The reported value is 240 C.)

Now draw a line on the nomograph from 20 C. to the density of 0.792. Locate the point where this line intersects a line for $T_c = 233$ C. A line through this point and 150 C. gives a density of 0.630. The density reported in International Critical Tables is 0.6495, indicating a nomograph error of 3%.

Values obtained from this chart were compared with reported data, at temperatures 100 deg. above the reference temperature, for 28 substances representing several classes of compounds. The average deviation found was 1.7%, the maximum 5.2%. This is sufficiently accurate for most engineering calculations.

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Design of Overhead Pipelines

When you find it desirable to run long pipelines on supports above ground, you'll want to provide for structural strength and for a self-draining line. Here's how it's done.

R. J. SWEENEY, R. J. Sweeney Engineering Associates

There may come a time when you'll find it desirable to run a long pipeline on poles or other supports above the ground level. For such a line, it is necessary to insure the structural strength of the pipe span as a beam between supports. And usually you'll want the pipeline to drain clean.

A method of approaching this problem will be outlined in this article. The approach given here will help solve the problem both adequately and quickly.

LOADING FACTORS

Normally, the loading on an overhead pipeline is made up of these three factors:

- The weight of the pipe.
- The weight of the contents.
- Horizontal wind loading.

Consider then, this illustrative calculation. We'll assume that we have a standard weight (Schedule 40) steel pipe. The pipe is full of water. This is a good approximation for most liquids and a possible condition for steam lines.

The wind loading acts horizontally on the pipeline at right angles to the gravity loading. We estimate the wind load at 32 lb./sq. ft. of projected area. This would be greater than that produced by a 100 mile per hr. wind.

In the table on the next page we have listed pipe weights and water weights for nine standard sizes of pipe. Adding pipe weight to water weight gives the total dead load. However, the wind loading must be added vectorially to obtain the total load listed in the table.

ALLOWABLE LENGTH

A pipeline strung continuously between supports is a continuous beam, with maximum bending moments at the supports. We can equate this maximum bending moment to the resisting moment of the pipe cross-section.

$$M_{Max} = -\frac{WL^2}{12} = \frac{SI}{C}$$

where,

M = Bending moment
W = Loading per unit length
L = Span
S = Maximum fiber stress
I = Moment of inertia
C = Radius to extreme fiber

From this relationship, we can arrive at

$$L^2 = \left(\frac{12S}{W}\right)\left(\frac{I}{C}\right)$$

If we take 20,000 psi. as the maximum allowable fiber stress, the resulting value for L is the maximum allowable span for each size of pipe. We have listed these values in the table.

With this span the pipe is safe in bending with a full liquid load and maximum wind load.

The maximum support reaction is the product of the combined loading and the span length. We have listed these values under the heading P in the last column of the table.

DEFLECTION

The deflection of a continuous beam is given by the following formula:

$$F = \frac{WL^4}{384EI}$$

where E is Young's modulus of elasticity of the pipe material. We will take E as 30,000,000 psi.

We are interested in the deflection because we want the line to drain clean. Under this condition, the pipe is emptying and the critical loading is that due to the pipe weight alone. Values for deflections and maximum spans are listed in the table.

Note that the deflections are

These Are the Factors You'll Need for Design

Pipe Size, In.	O.D. In.	I In.⁴	Loading In Pounds Per Foot					L Ft.	F In.	Elev. Ft.	P Lb.
			Pipe	Water	Dead	Wind	Total				
2	2.375	0.666	3.65	1.45	5.10	6.30	8.11	37.2	1.58	0.41	302
2.5	2.875	1.530	5.79	2.08	7.87	7.68	11.00	42.5	1.86	0.48	467
3	3.500	3.017	7.58	3.22	10.80	9.35	14.26	49.2	2.21	0.57	700
4	4.500	7.233	10.79	5.50	16.29	12.05	20.2	56.5	2.28	0.59	1,140
5	5.563	15.16	14.62	8.67	23.29	14.85	27.7	62.8	2.31	0.59	1,740
6	6.625	28.14	18.97	12.54	31.51	17.68	36.2	68.6	2.23	0.57	2,480
8	8.625	72.49	28.55	21.70	50.25	23.0	55.3	78.0	2.19	0.56	4,320
10	10.75	160.7	40.48	34.13	74.61	28.6	79.8	86.6	2.12	0.54	6,910
12	12.75	279.3	49.56	48.70	98.26	34.2	104.0	92.0	1.90	0.49	9,560

practically uniform for the various pipe sizes.

DRAINING

With pipe supports at a uniform elevation, the sag in a pipe caused by elastic deflection will form pockets that will not drain. However, if successive support elevations are on a sufficient gradient, the pipe can be made to be self-draining.

The criterion is that there shall be no negative slope or downgrade in the direction of increasing support elevations. This criterion will be satisfied if the general support gradient either equals or exceeds the maximum elastic slope of the pipe.

In general the slope of an elastic beam is

$$G = \int \frac{M}{EI}\,dx$$

The maximum slope occurs at the points of inflection of the continuous beam where the moment is zero. The general moment is

$$M_x = -\frac{WL^2}{2}\left(\frac{1}{6} - \frac{x}{L} + \frac{x^2}{L^2}\right)$$

At $M = 0$,
$x/L = 0.2113$ and 0.7887

Substituting the expression for moment into the slope formula,

$$G = \frac{WL^2}{2EI}\int\left(\frac{1}{6} - \frac{x}{L} + \frac{x^2}{L^2}\right)dx$$

and G is a maximum when $x/L = 0.2113$.

$$G_{Max} = WL^2/64.4EI$$

Now, what is the elevation required from pole to pole so that the actual slope of the pipe will be nowhere negative? Well,

$$\text{Elev.} = GL$$

Therefore,

$$\text{Elev.} = WL^4/64.4EI$$

This expression is in the same form as the maximum elastic deflection, F, except for the value of constant.

$$\text{Elev.} = (384/64.4)F = 5.97F$$

or about six times the deflection.

Based on this relationship, we have calculated the required elevation for drainage and listed the values in the table. The relation between elastic deflection and pole support elevation allows us to calculate the elevation requirement easily for other conditions than for those tabulated.



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PIPELINE LAYOUT

The layout of a pipeline, then, involves these steps:

- Determine the maximum support span.
- Locate the poles on the terrain.
- Calculate the elevation of the pipe at each pole.

As the line becomes progressively higher, the pole height may be undesirably high on level terrain. Periodically the line may be dropped to the low limit, with a draining connection at each low point. These drops will provide expansion flexibility.

Ingenuity will suggest setting the vertical profile to give high points at road crossings, etc., and low points where anchors are needed.

EXPERIMENTAL DATA

A discussion of this problem is given in the Crane Co. catalog No. 42, p. 550, based on experimental data. Crane reports that pipes larger than 2 in. at the test spans deflected substantially in accordance with the fixed-end beam formula. Pipes smaller than 2 in. deflected more than the formula value—indicating plastic deformation at the high-stress point at the support. A chart is given for determing deflection and gradient, but this has no reference to the structural strength of the pipe-beam.

The Crane Co. test spans used standard size pipelines filled with water, in pipe sizes ¾-in. to 4-in. inclusive.

Chemical Engineering Fundamentals

Reactor Design Problem: Complex Reaction

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IN THE past few months we have developed kinetic equations and described their use in reactor design. This month we will apply some of these principles to the solution of a practical problem.

This problem is very real in the sense that both of the authors have encountered similar problems in industry, although our fields of research have been quite different. The successful solution of the problem emphasizes the utility of kinetic analysis in reactions where time is not the controlling factor, but where product distribution and the relative ratios of reactants in competing reactions are significant.

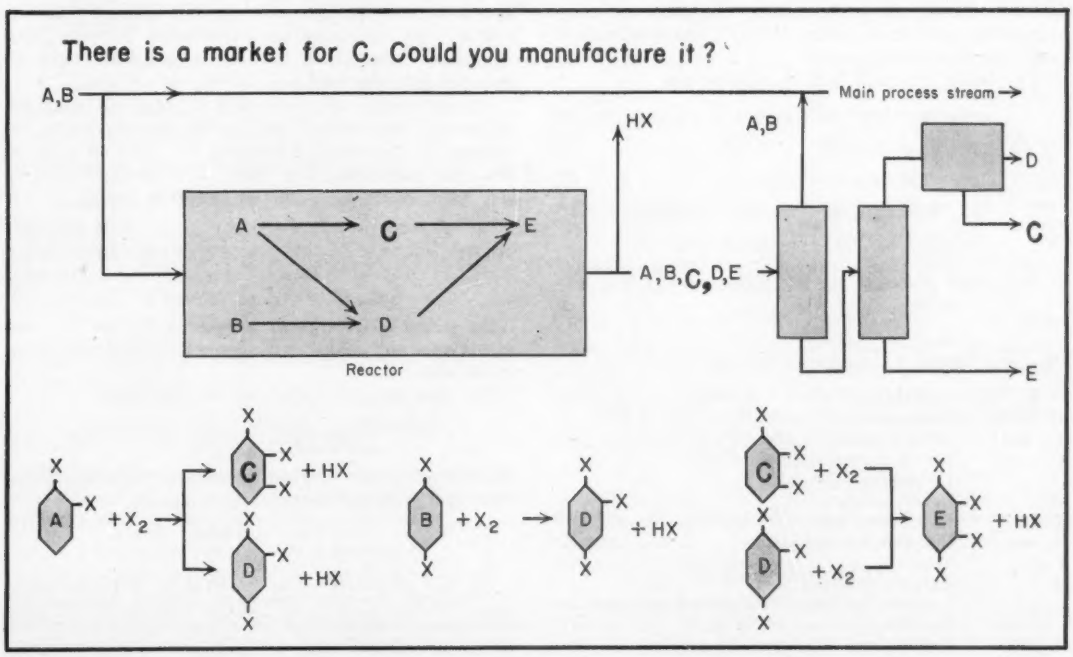
What the Problem Is

A plant has been designed for making a halogenated aromatic as a byproduct. The main plant produces a process stream consisting of a mixture of *o-* and *p-* isomers of the dihalogenated material. A market has developed for comparatively small amounts of the *1,2,3-* isomer of the trihalogenated material.

A quick study of the possibility of producing this trihalogenated material revealed these facts:

- It is practically impossible to separate the *o-* and *p-* isomers of the dihalogenated aromatic.
- The desired *1,2,3-* isomer is readily separated by crystallization from other trihalogenated isomers.
- We can get fairly good yields of the desired product by halogenating the mixed feed stream, although some tetrahalogenated material is also produced.

Based on these facts, a bench-scale study was made of the reactions involved. The resulting laboratory data served as the basis for design of a small plant. The laboratory studies showed that the reactions are almost instantaneous. Absorption of the halogen into the feed is the rate-controlling factor. The rate of absorption is apparently quite



rapid. Conclusion: The reaction should be an easy one to run in the plant.

The plant was built on this basis. But here's what happened when the plant actually started operating:

- Yield of the *1,2,3-* isomer was much (28%) lower than anticipated.
- Tetra production was almost 60% higher than design.

At this point the engineers who had designed the plant began a complete kinetic analysis of the reactions involved, trying to figure out what had gone wrong. (Yes, this analysis should have been made in advance. But too often it is made only after trouble is encountered.)

This is where we join this problem. Suppose we are the design engineers on this job. What do we do now?

We'd Use Kinetic Analysis

In the sketch above we show all the reactions involved in the design problem, a flowsheet and a somewhat simplified notation system that we'll use in our discussion. In the original design of the plant, 0.70 moles of halogen are added per mole of feed and 0.246 moles of C are produced along with 0.215 moles of D and 0.118 moles of E. Laboratory data confirming this basis are shown in the tables at the right.

However, in the operating plant when 0.70 moles of halogen were added per mole of feed, only 0.176 moles of C were produced along with 0.156 moles of D and 0.184 moles of E.

To make a kinetic study we must first postulate a mechanism for the reaction and check it with the laboratory data. We'll assume that each reaction is of simple order; develop integral equations for product distribution; evaluate the relative rate constants; and then compare our calculated values with the laboratory results.*

The basic reaction rate equations are

$$dC_A/dt = -(k_1 + k_2)C_A C_{X_2} \quad (1)$$

$$dC_B/dt = -k_2 C_B C_{X_2} \quad (2)$$

$$dC_C/dt = k_1 C_A C_{X_2} - k_4 C_C C_{X_2} \quad (3)$$

$$dC_D/dt = k_2 C_A C_{X_2} + k_3 C_B C_{X_2} - k_5 C_D C_{X_2} \quad (4)$$

$$dC_E/dt = k_4 C_C C_{X_2} + k_5 C_D C_{X_2} \quad (5)$$

We could also set up an equation for the disappearance of X_2. However, in this type of reaction system the concentration of halogen is essentially constant, determined by the absorption rate of halogen into the feed.

To determine whether this scheme of reactions is correct and to find values for the constants, we can set up rate ratio equations by dividing each of the rate equations, Eqs. (2), (3), (4) and (5), by Eq. (1). Starting with the equation for C_B,

$$\frac{dC_B/dt}{dC_A/dt} = \frac{-k_2 C_B C_{X_2}}{-(k_1 + k_2)C_A C_{X_2}}$$

$$dC_B/dC_A = k_2 C_B/(k_1 + k_2)C_A \quad (6)$$

This differential equation relates C_B to C_A and eliminates both halogen concentration and time from consideration.

We can integrate Eq. (6) to this form

$$C_B = I_1 C_A^{\,b}, \quad \text{where} \quad b = k_2/(k_1 + k_2);$$
$$\text{and where} \quad k_2/(k_1 + k_2) = \kappa_2$$

Substituting the original conditions into the equation evaluates the integration constant.

$$I_1 = C_{Bo}/C_{Ao}^{\,b}, \quad \text{where} \quad b = \kappa_2$$

Experimental Data for Mixed Halogenations

Feed Composition: $C_{Ao} = 0.35$ lb.-moles/cu. ft.
$C_{Bo} = 0.15$ lb.-moles/cu. ft.

Lb.-Moles of X_2 Added Per Lb.-Mole of Feed	C_A	C_B	C_C	C_D	C_E
0	0.350	0.150	0	0	0
0.20	0.279	0.126	0.050	0.040	0.005
0.40	0.217	0.103	0.087	0.073	0.020
0.60	0.164	0.080	0.115	0.098	0.043
0.70	0.140	0.070	0.123	0.108	0.059
0.80	0.118	0.063	0.127	0.113	0.079
0.90	0.097	0.053	0.130	0.120	0.100
1.00	0.080	0.044	0.130	0.122	0.124

Feed Composition: $C_{Co} = 0.25$ lb.-moles/cu. ft.
$C_{Do} = 0.25$ lb.-moles/cu. ft.

Lb.-Moles of X_2 Added Per Lb.-Mole of Feed	C_C	C_D	C_E
0	0.250	0.250	0
0.40	0.142	0.158	0.200
0.60	0.088	0.112	0.300
1.00	0	0	0.500

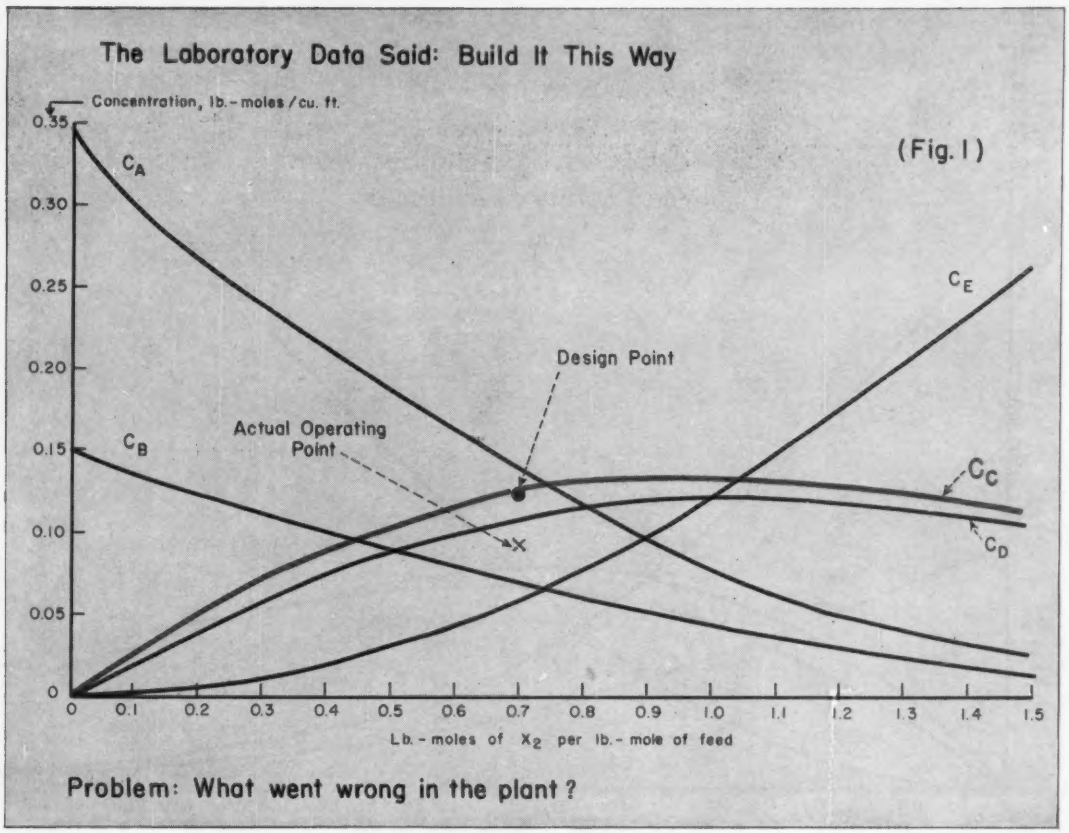
Feed Composition: Pure B
$C_{Bo} = 0.50$ lb.-moles/cu. ft.

Lb.-Moles of X_2 Added Per Lb.-Mole of Feed	C_B	C_D	C_E	α	β
0	0.500	0	0	0	1.0
0.40	0.329	0.142	0.029	0.432	1.52
0.60	0.261	0.178	0.061	0.682	1.915
1.00	0.146	0.208	0.146	1.427	3.425

Nomenclature (Consistent Units)

A, B	Reactants
C, D, E	Products
C_A, etc.	Concentration of A, etc.
C_{Ao}, etc.	Initial concentration of A, etc.
d	Differential operator
HX	Reaction coproduct
I_1, I_2	Integration factors
k_1, etc.	Reaction rate constants
t	Time
X_2	Halogen reactant
α, β, γ	Substitution terms in a general equation, see Eq. (16).
κ	General reaction rate ratio constant
κ_2, κ_3, etc.	Specific reaction rate ratio constants

* A very similar case was presented by R. B. MacMullin, "Distribution Reaction Products in Benzene Chlorination—Batch Versus Continuous Process Procedures," *Chemical Eng. Progress*, Vol. 44, p. 183 (1948). The methods were further developed by J. W. Churchill, Olin Mathieson Chemical Corp., Niagara Falls, N. Y. and T. M. Jenney, Becco Chemical Co., Buffalo, N. Y.



And the integrated, more useful form of the equation becomes

$$C_B = C_{Bo}(C_A/C_{Ao})^b, \quad \text{where} \quad b = \kappa_3 \tag{7}$$

To solve for κ_3 we can put the equation into the logarithmic form.

$$\kappa_3 = \ln (C_B/C_{Bo})/\ln (C_A/C_{Ao}) \tag{8}$$

Using experimental values,

$$\kappa_3 = \ln (0.070/0.150)/\ln (0.140/0.350) = 0.80 \tag{9}$$

We can check Eq. (9) by putting in another value of C_A and comparing the result with the experimental data. For example, using the value of $C_A = 0.097$,

$$C_B = 0.150(0.097/0.350)^{0.80} = 0.053$$

which is a good check on the experimental data (see tables on p. 202).

The Other Rate Ratio Constants

We have now evaluated κ_3, the rate ratio constant equal to $k_3/(k_1 + k_2)$. In a similar manner we can evaluate each of the other rate ratio constants.

$$\kappa_1 = k_1/(k_1 + k_2) \qquad \kappa_2 = k_2/(k_1 + k_2)$$
$$\kappa_4 = k_4/(k_1 + k_2) \qquad \kappa_5 = k_5/(k_1 + k_2)$$

The easiest of these to evaluate are κ_4 and κ_5.

We can get the ratio of $k_4/k_5 = \kappa_4/\kappa_5$ exactly as we got the ratio of $k_3/(k_1 + k_2)$, by running a laboratory test, this time on the halogenation of a mixture of C and D. The reactions involved are:

$$\left.\begin{matrix} C + X_2 \\ D + X_2 \end{matrix}\right\} \rightarrow E$$

The differential reaction rate equations are:

$$dC_C/dt = -k_4 C_C C_{X_2} \tag{10}$$

$$dC_D/dt = -k_5 C_D C_{X_2} \tag{11}$$

As before, this can be integrated to the form

$$C_D = C_{Do}(C_C/C_{Co})^b \quad \text{where} \quad b = k_5/k_4 \tag{12}$$

Solving this and checking with the laboratory data on p. 202, we find that

$$k_5/k_4 = 0.80 = \kappa_5/\kappa_4 \tag{13}$$

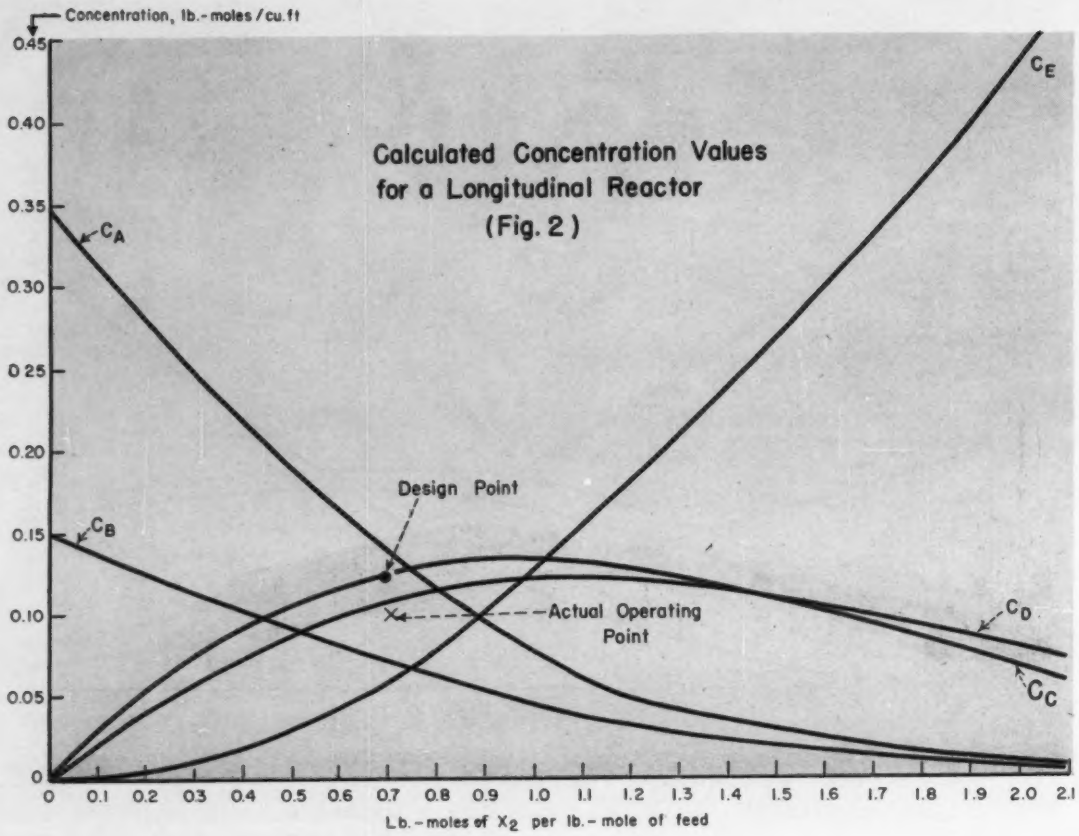
The next easiest step—we always save the hardest 'til last—is to evaluate the ratio $k_5/k_3 = \kappa_5/\kappa_3$. Again we will run some laboratory tests. By isolating some pure B and halogenating it, we can collect data on the relatively simple system

$$B \xrightarrow{X_2} D \xrightarrow{X_2} E$$

And the differential rate equations reduce to the following form:

$$dC_D/dC_B = (k_5 C_D/k_3 C_B) - 1 \tag{14}$$

We have shown previously (*Chem. Eng.*, Feb. 1956, p. 193) that when $C_{Do} = 0$, Eq. (14) can be integrated to the form (*Continued p. 204*)



$$C_D = \frac{C_B}{\kappa - 1} - \frac{1}{\kappa - 1}\left(C_{Bo}\right)^{1-\kappa}\left(C_B\right)^{\kappa} \qquad (15)$$

where $\kappa = k_3/k_2$

If we simplify this equation a little, we'll see that it can be solved for κ quite readily. Let's first collect a few terms and rearrange the equation.

$$C_D = \frac{C_B}{\kappa - 1}\left[1 - (C_B/C_{Bo})\right]^{\kappa-1}$$

Then divide by C_B.

$$C_D/C_B = [1/(\kappa - 1)][1 - (C_B/C_{Bo})]^{\kappa-1}$$

Now let $\alpha = C_D/C_B$; $\beta = C_{Bo}/C_B$; and let $\gamma = 1 - \kappa$. Then,

$$\alpha = [1/-\gamma][1 - (1/\beta)^{-\gamma}]$$

or,

$$\alpha = (\beta^{\gamma} - 1)/\gamma \qquad (16)$$

Now by using the data from our test runs (see tables on p. 202) we can solve Eq. (16). By trial and error we find that $\gamma = 0.50$. Then $\kappa = 0.50$, or $k_2/k_3 = 0.50$. But we have already shown in Eq. (9) that $\kappa_3 = 0.80$. Therefore,

$$\kappa_2 = (k_2/k_3)\kappa_3 = (0.50)(0.80) = 0.40 \qquad (17)$$

We have also shown, in Eq. (13) that κ_2/κ_4 is equal to 0.80. Therefore,

$$\kappa_4 = 0.40/0.80 = 0.50 \qquad (18)$$

Now For the Hard Ones

Now, maybe we can go back and get κ_1 and κ_2. If we divide Eq. (2) by Eq. (1), we get

$$dC_C/dC_A = -\frac{k_1}{k_1 + k_2} + \frac{k_4 C_C}{(k_1 + k_2)C_A}$$

$$dC_C/dC_A = -\kappa_1 + \kappa_4(C_C/C_A) \qquad (19)$$

This can be integrated to the form

$$C_C = -\kappa_1 C_A/(1 - b) + I_2 C_A^{\,b} \qquad (20)$$

where $b = \kappa_4$

Product Distribution Equations

Longitudinal Reactors

$$C_A = C_A$$

$$C_B = C_{Bo}\,(C_A/C_{Ao})^{\kappa_3}$$

$$C_C = [\kappa_1/(1 - \kappa_4)]\,[C_{Ao}{}^{1-\kappa_4}\,C_A{}^{\kappa_4} - C_A]$$

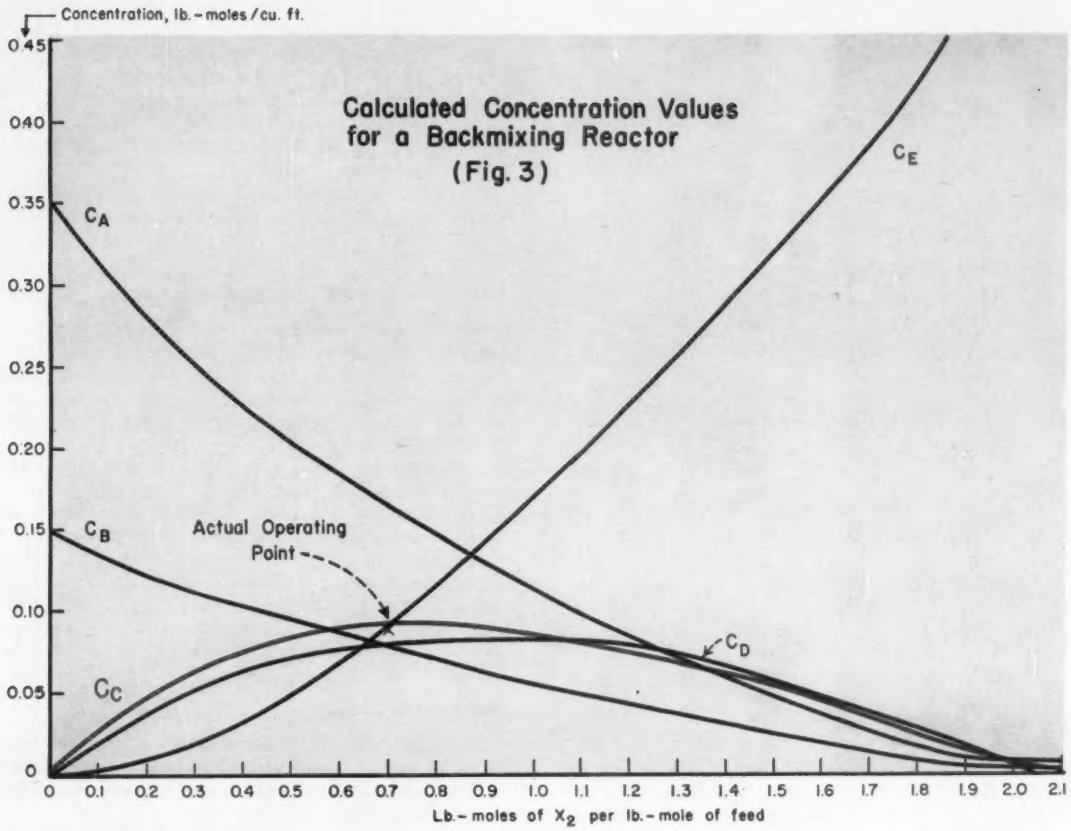
$$C_D = [\kappa_2/(1 - \kappa_3)]\,[C_{Ao}{}^{1-\kappa_3}\,C_A{}^{\kappa_3} - C_A] + [\kappa_2/(\kappa_3 - \kappa_4)]\,[C_{Bo}C_{Ao}{}^{-\kappa_3}C_A{}^{\kappa_3} - C_B]$$

$$C_E = C_{Ao} + C_{Bo} - C_A - C_B - C_C - C_D$$

$$\text{Moles } X_2 = (C_C + C_D + 2C_E)/(C_{Ao} + C_{Bo})$$

Relative Reaction Rate Constants

$\kappa_1 = 0.75$; $\kappa_2 = 0.25$; $\kappa_3 = 0.80$;



If we start with $C_{C_0} = 0$, we can evaluate the integration constant I_2 and arrive at the following equation:

$$C_C = [\kappa_1/(1-b)][C_{A_0}{}^{1-b} C_A{}^b - C_A] \qquad (21)$$

where once again $b = \kappa_4$

By substituting as we did above we can get an equation of the general form

$$\alpha = (\beta^\gamma - 1)/\gamma$$

which we can solve by trial and error from the experimental data. We find that $\kappa_4/\kappa_1 = 0.667$. But we know from Eq. (18) that $\kappa_4 = 0.50$. Thus,

$$\kappa_1 = 0.50/0.667 = 0.75 \qquad (22)$$

And We're Down to One Unknown

This leaves us with the job of evaluating κ_2. But by our definition of the rate ratio constant, $\kappa_1 + \kappa_2$ must equal 1.0. So,

$$\kappa_2 = 1.0 - \kappa_1 = 1.0 - 0.75 = 0.25 \qquad (23)$$

However, we wish to point out that in this type of work, the trial and error solutions may be extremely sentitive to small changes in the substituted values. To obtain accurate answers, the greatest possible accuracy should be carried all the way through the intermediate calculations.

Slide-rule accuracy is usually not enough. For our work on this problem we had to use a desk calculator and a table of logarithms. Admittedly, this increases the time required to perform the calculations. However, it is required to keep the solution within the limits of engineering accuracy.

Calculating the Product Distribution

Having arrived at the relative values for the reaction rate constants by a relatively roundabout route, we can now calculate values of C_B, C_C, C_D and

---

Backmix Reactors

$$C_A = C_A$$

$$C_B = C_{B_0}/[1 + (\kappa_3/C_A)\,(C_{A_0} - C_A)]$$

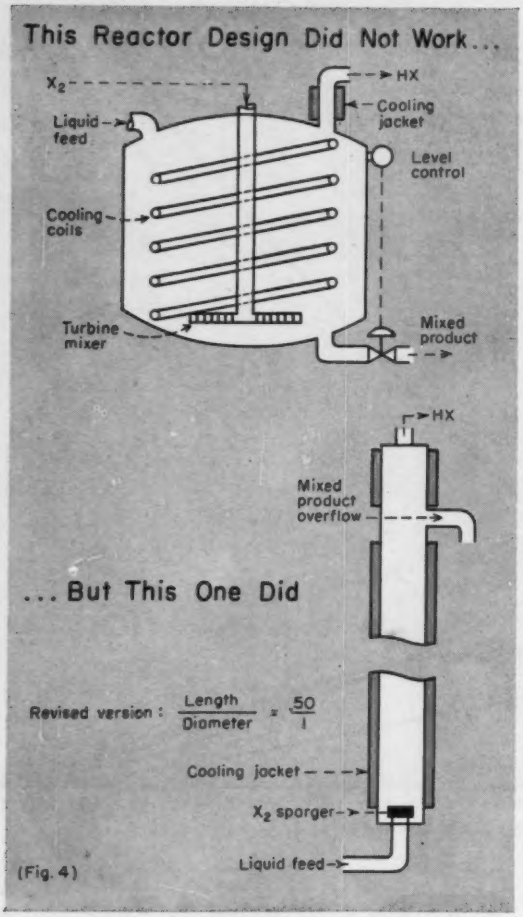
$$C_C = [\kappa_1 C_A\,(C_{A_0} - C_A)]/[C_A \kappa_4\,(C_{A_0} - C_A)]$$

$$C_D = \frac{(\kappa_2 C_A + \kappa_3 C_B)\,(C_{A_0} - C_A)}{C_A - \kappa_3\,(C_{A_0} - C_A)}$$

$$C_E = C_{A_0} + C_{B_0} - C_A - C_B - C_C - C_D$$

$$\text{Moles } X_2 = (C_C + C_D + 2C_E)/(C_{A_0} + C_{B_0})$$

$\kappa_4 = 0.50$; $\kappa_3 = 0.40$



C_B for a series of values of C_A. Then we can check our calculated values against the experimental data that are available.

We have done this in Fig. 2 on p. 204. We get an excellent check with the laboratory data. So now we can be sure that the data were pretty good and that the constants we have calculated are all right for further use.

What Went Wrong In the Plant?

Well then, why don't the plant operating results check with these calculated data? Well, backmixing in the reactor might be one cause. What effect would backmixing in the reactor have on these reactions?

By a material balance, we can get distribution equations in the case of a backmixing reactor, as we have done in previous examples (*Chem. Eng.* Feb. 1956, p. 193). The table on p. 204 summarizes these product distribution equations.

We can now calculate the product distributions for a series of values of C_A and draw curves (see Fig. 3) for the case of a backmix reactor. Then we can compare the backmix curves with those that we have calculated for the batch or longitudinal case.

We can see from Fig. 3 that the product distribution in the operating plant approaches very close to that predicted by the calculated backmixing curves. Thus, at 0.70 moles of X_3 per mole of feed, the distribution is 0.164 moles of A, 0.078 moles of B, 0.088 moles of C, 0.078 moles of D and 0.092 moles of E per cu. ft. of reactor volume. This is almost exactly the plant result.

So even in reactions that are almost instantaneous, backmixing can cause significant changes in product distribution.

Our New Design Recommendations

On this basis our design recommendations would be along this line:

• Replace the original turbo-mixer reactor with a simple tubular absorber. This will decrease the amount of backmixing and give a more favorable product distribution.

Although this was a fictitious problem and the data were made up expressly for the purpose of illustration, we can speculate rather reliably on what would occur in a real case. When we install the new longitudinal reactor, we will get results in the plant that coincide with the original design predictions. The new reactor gives essentially longitudinal operation. Fig. 4 is a schematic drawing showing the old and the new plant reactors.

Some Conclusions

We feel that this problem shows fairly well how kinetics can be used by the production man as well as the development and research engineer. (See *Chem. Eng.*, Aug. 1955, p. 199.)

At this point we'll conclude our review of kinetics as used in homogeneous reactor design and next month we'll look at the use of kinetics in the design of reactors for heterogeneous reactions.

NOTE—*Earle Young changed jobs at the beginning of the year. He is now associated with the Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh, Pa. Dr. Corrigan can be addressed care of Olin Mathieson, Brandenburg, Ky.*—EDITOR.

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The Udex and Paraxylene Plants described here were designed and constructed for Sinclair Refining Company, Marcus Hook, Pa.

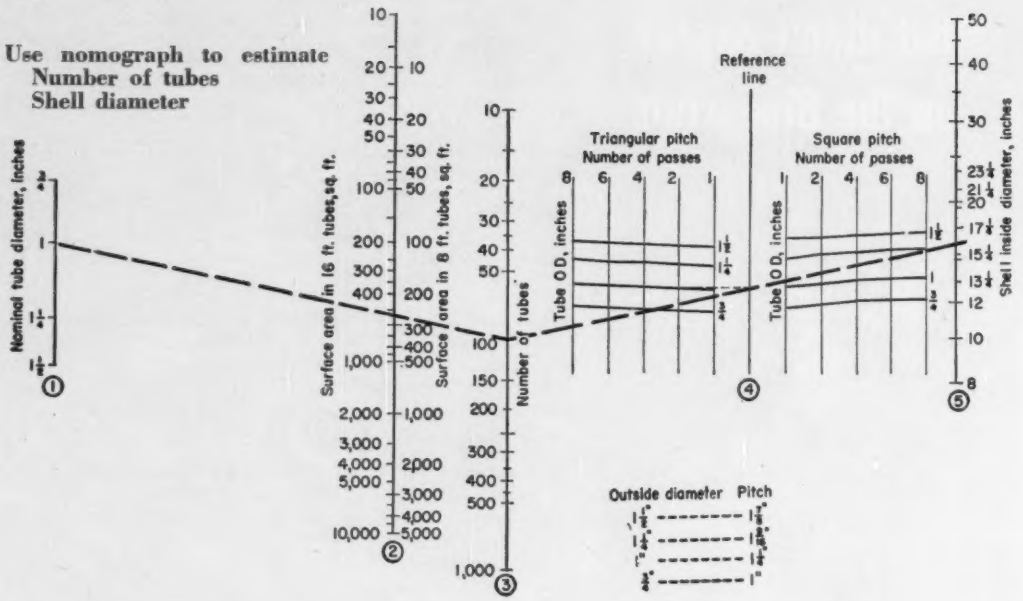
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Make Your Heat Exchanger Design Estimates More Complete

Michael A. Auro* and Edward A. Andres*

Respt., Sp-1 and Pvt, 9766th Technical Unit, U. S. Army, Camp Detrick, Md.

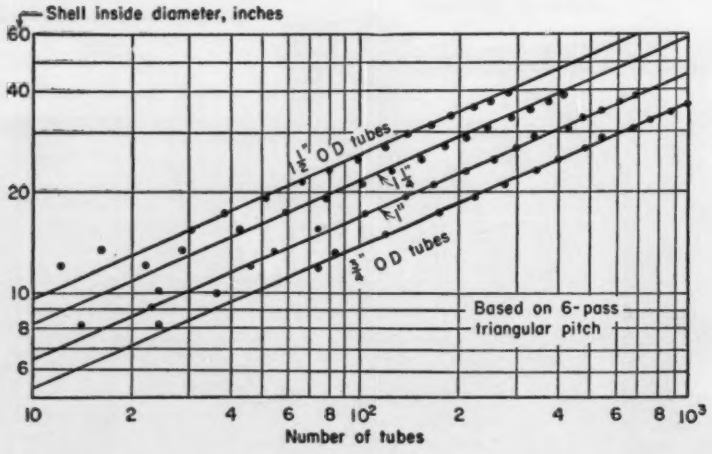
In preliminary design estimates of heat exchangers, it is often desirable to be able to specify the approximate number of tubes; their arrangement in the tube bundle, and shell size which will accommodate them.

* Respectively, formerly with M. W. Kellogg Co., New York; and Delco Products Div., General Motors Corp.

Kern ("Process Heat Transfer," p. 841-2, McGraw-Hill, New York) presents a table in which such values have been tabulated for 8-39-in. diameter heat exchangers.

In order to present this information in an empirical equation, the data given in this table were plotted to see if a correlation of any sort was possible.

For a specified number of tube passes and a set tube sheet arrangement, at a constant tube size, one would expect that a plot of the number of tubes N vs. the shell inside diameter would result in a straight line on log-log paper. Figure below presents such data for 6-pass, triangular-pitch exchangers with various tube sizes.



The equation for the data may be expressed as:

$$\text{Log } N = M_1 \text{ Log } (ID) \text{ Shell} + \text{Log (Intercept } A). \quad (1)$$

Intercept values were correlated by plotting them vs. tube diameter on semilog paper, and gave the following relation:

$$\text{Log } A = M_2 T + \text{Log (Intercept } C) \quad (2)$$

Combining Equations (1) and (2) we have.

$$\text{Log } N = M_1 \text{ Log } (ID) \text{ Shell} + M_2 T + \text{Log (Intercept } C) \quad (3)$$

Here N = number of tubes; ID = inside diameter of shell,

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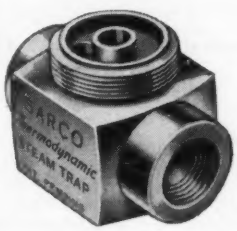
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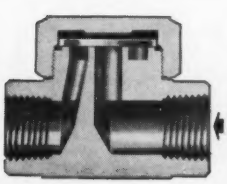
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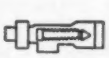
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inches; M_1 = slope of shell ID vs. number of tubes plot; M_2 = slope of intercept vs. tube OD plot; T = tube outside diameter, inches; C = intercept of individual intercept vs. tube OD plot, and A = intercept of number of tubes vs. shell ID plot.

Correlations were obtained for 1-, 2-, 4-, 6-, and 8-pass exchangers with both triangular and square pitch tube arrangements.

The nomogram was prepared based on Equation (3), applying the determinant method presented by Allcock *et al* ("The Nomogram," 4th Ed. Pittman, London).

Most heat exchangers are designed with either an 8-ft. or 16-ft. tube length. Once the number of tubes required, the tube diameter and the tube length are known, then the total surface area for heat transfer can be calculated.

Accordingly, the nomogram was extended to include relations with which to estimate the number of tubes to give a required transfer area.

A typical calculation using the nomogram follows:

Previous calculations have indicated that a heat transfer area of 530 sq. ft. is required. Similarly, flow rates of the material being processed indicate that a 1-in. diameter tube is needed.

You would now like to know how many 16-ft. tubes, with a triangular pitch arrangement, will fit in what size 2-pass unit.

From 1-in. tube diameter on Scale (1) extend a straightedge through 530 sq. ft. on Scale (2), projecting to Scale (3) at 100 tubes.

In the grid section for triangular pitch tube arrangements locate the point corresponding to 2 passes with 1-in. OD tubes, and project horizon fully to the reference line (4).

Now extend the straightedge from 100 tubes on Scale (3), through the point just found on reference line (4), to intersect Scale (5) near the pipe size corresponding to an ID of 17¼ in. Kern reports that a 17¼-in. shell is adequate. To summarize, then, the exchanger will have 100 tubes, 16 ft. long and 1 in. OD, arranged in 2 passes on triangular pitch. The bundle will fit into a 17¼-in. ID shell.

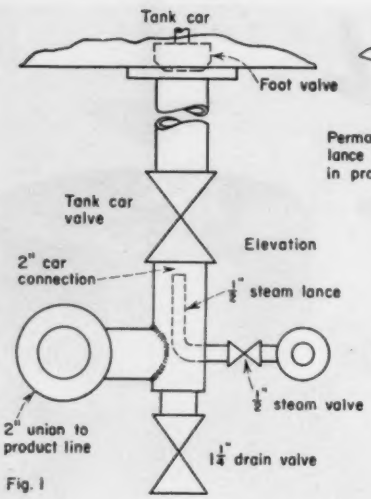


Fig. 1

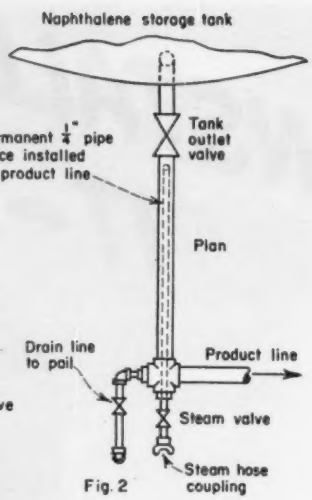


Fig. 2

Steam Lances Insure Naphthalene Flow

S. G. Hazel

Senior Safety Engineer, The Sherwin-Williams Co., Chicago, Ill.

Two prize winning improvements in the handling of naphthalene developed by Manuel Lira of our Mechanical Department should be of value to all others who handle either naphthalene or materials of similar characteristics.

Fig. 1 shows a special naphthalene car-unloading fitting which eliminates any chance of steam pressure build-up in the car while attempting to free the foot valves on the tank car by melting the solidified naphthalene. Normally, in melting-free, the sudden release of confined steam creates a tremendous force, spewing out hot molten naphthalene from the dome of the tank car. However, use of the new unloading fitting permits the operator to free the foot valve of the car without any danger of erupting hot naph-

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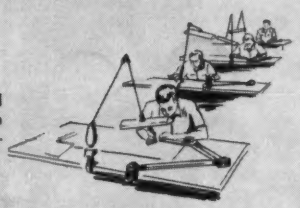
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thalene through the dome. Its built-in steam lance enables steam to be applied to the foot valve without confining the steam.

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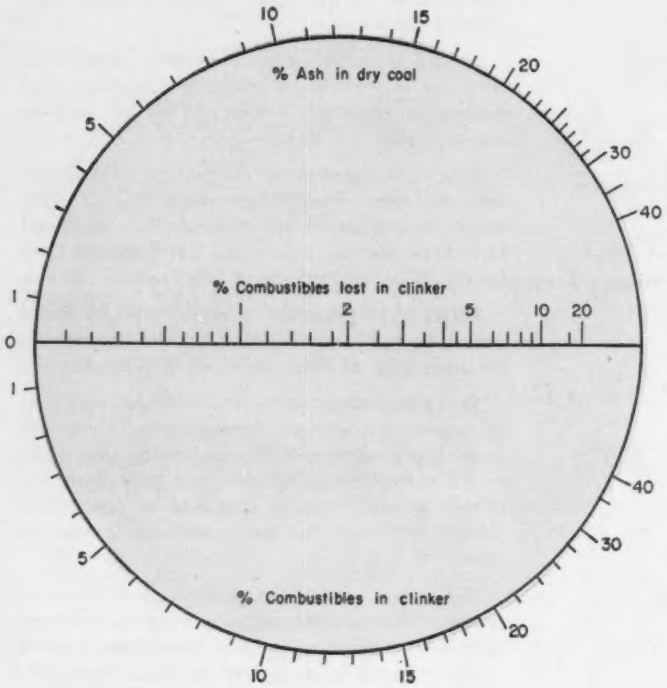


Chart Computes Fuel Lost in Clinker

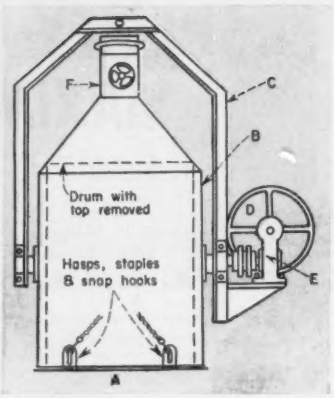
George E. Mapstone
Boksburg North, Transvaal, South Africa.

If the maximum boiler efficiency is to be maintained it is essential that the amount of combustibles which are unburnt and are lost in the clinker should be kept to a minimum. These lost combustibles can be determined simply enough by analysis of a representative sample of the clinker and, if the ash content of the coal fed to the boiler has also been determined, the relative loss of fuel can be calculated from the relationship

$$P = \frac{100AC}{(100 - A)(100 - C)}$$

where P = % of combustibles lost to clinker; A = % of ash in coal; and C = % of combustibles in clinker.

The accompanying chart has been designed to solve this relationship simply and conveniently. To use the chart connect with a straightedge the ash content of the coal on the upper semicircle, to the combustible content of the clinker on the lower semicircle. Then read off the combustible loss on the diameter that separates upper and lower scales.



Charging Hopper for Free-Flowing Solids

N. R. Beckwith
Beckers Pty, Ltd.
Dudley Park, South Australia

It is often necessary to transfer material from drums to charging hoppers for autoclaves, etc., and this task can be time-consuming and unpleasant, particularly if the granular or flake materials contain fine dust which is irritating or dangerous.

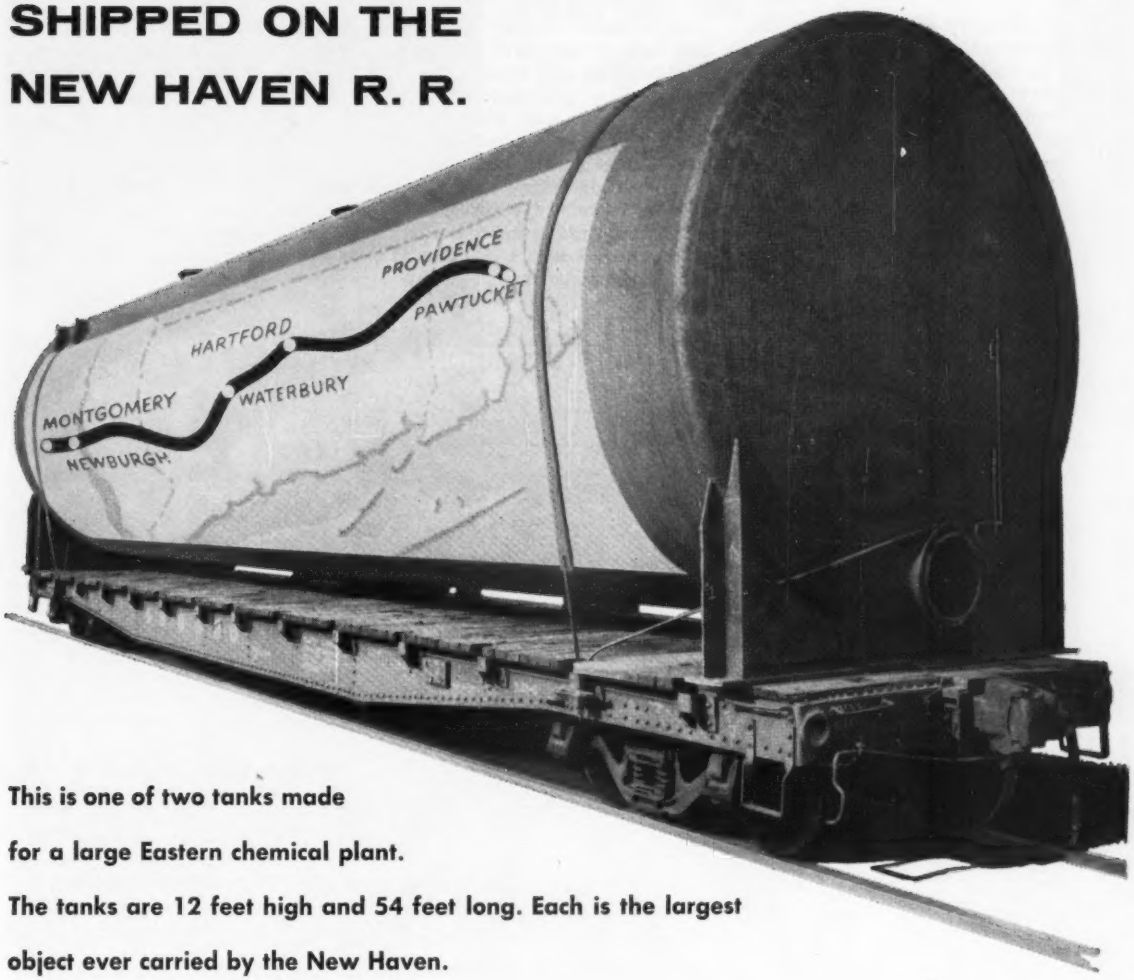
The following equipment was designed for charging flake sodium sulfide, which is dusty to handle and irritating if it makes contact with the skin or nasal passages. It is essential that the materials handled with this equipment are of a free-flowing nature.

The unit consists of a circular steel plate A attached to a hopper by three hasps and staples. The hopper B is held in a bridle C so that the hopper can be rotated by turning a hand wheel D through a suitable worm type gear box E. A steering gear box from an old car is quite suitable. The discharge valve F consists of a flap hinged on one edge and controlled by a coarse threaded spindle operating through a swivelled yoke. The bridle is placed on a hook of a suitable hoist (preferably electric or air-operated) which is hung from a trolley running along an overhead beam to the autoclave or vessel to be charged.

The method of operation is as follows:

1. Place circular plate A under overhead beam and slide drum of material onto plate.

BIGGEST THING EVER SHIPPED ON THE NEW HAVEN R. R.



This is one of two tanks made for a large Eastern chemical plant. The tanks are 12 feet high and 54 feet long. Each is the largest object ever carried by the New Haven.

The acid storage requirements of this modern plant called for these two specially designed tanks—and U.S. Permobond® lining was chosen to properly protect them. But the immense size of the tanks set up a problem: the bridges, tunnels and overpasses on the railroad made normal routing out of the question.

Working with the railroad's traffic department, "U. S." arranged a special routing for the tanks—from the steel fabricating plant to the "U. S." plant in Providence (where the tanks were lined) and then to the site of the chemical plant. The map on the side of the tank (above) shows the route from fabricating plant to Providence.

For protection against corrosion of tanks, piping, valves—get in touch with "U. S." technicians through Mechanical Goods Division, United States Rubber, Rockefeller Center, New York 20, New York.

Mechanical Goods Division

United States Rubber

2. Remove lid from drum, using suitable drum cutter.

3. Using electric or air hoist, lower the inverted hopper over the drum and locate so that hasps and staples match up. Attach quick action snap-hooks to prevent movement of plate.

4. Raise unit to convenient height with hoist and turn handwheel which rotates hopper and drum through 180°.

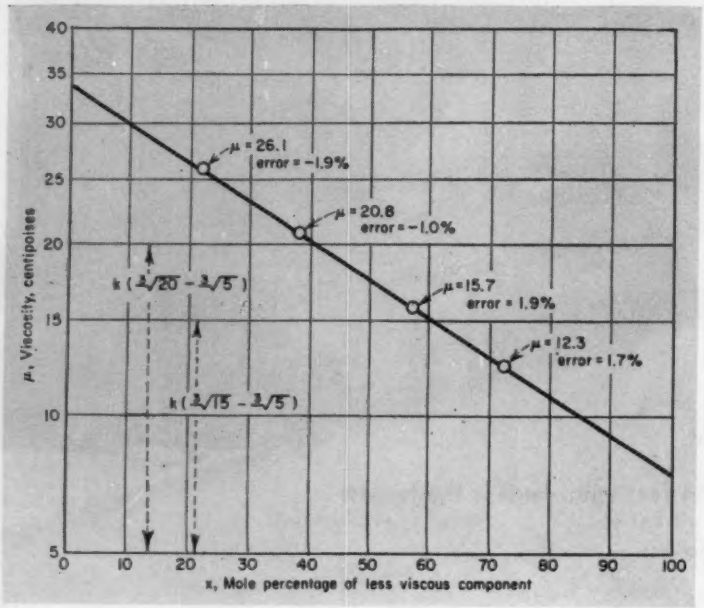
5. Transfer hopper to charging hole of autoclave or vessel, using trolley and hoist.

6. Open quick-flowing discharge valve and contents of drum will now run out of hopper. The rate of flow can be controlled by discharge valve.

7. When empty, reverse above procedure and remove empty drum.

If a complete drum is not required, excess material can be run out into a weighed drum on a scale located under overhead beam. The balance of material can then be transferred to the autoclave or vessel.

The above equipment has been used successfully on flake sodium sulfide, but it can be used for any solid chemical of a free-flowing nature, e.g., flake or granular caustic soda.



Aid for Estimating Viscosity of Blends

D. S. Davis

Professor of Chemical Engineering, Virginia Polytechnic Inst., Blacksburg, Va.

Chemists and engineers have found that special plotting papers that permit nonlinear data to be plotted as straight lines are extremely convenient and valuable time savers. A special plotting paper designed for convenience in predicting the viscosities of blended liquids is presented here. On this paper abscissas are represented by a uniform scale that runs from 0 to 100%, while ordinates are represented by a nonuniform scale that extends, in this case from 5 to 40 centipoises. Abscissas are used for percentage compositions and ordinates for viscosities. The ordinate scale is really a scale of cube roots and can be laid off most conveniently through reference to a cube root table as found in any of the handbooks.

The cube root ruling of the paper arises from an investigation by Kendall and Monroe[1], who proposed the following equation for handling viscosities of blended liquids:

$$\sqrt[3]{\mu} = x\sqrt[3]{\mu_1} + (1 - x)\sqrt[3]{\mu_2}$$

where M = absolute viscosity of the blend; M_1 = absolute viscosity of the less viscous component; M_2 = absolute viscosity of the more viscous component; and x = mole percentage of the viscous component.

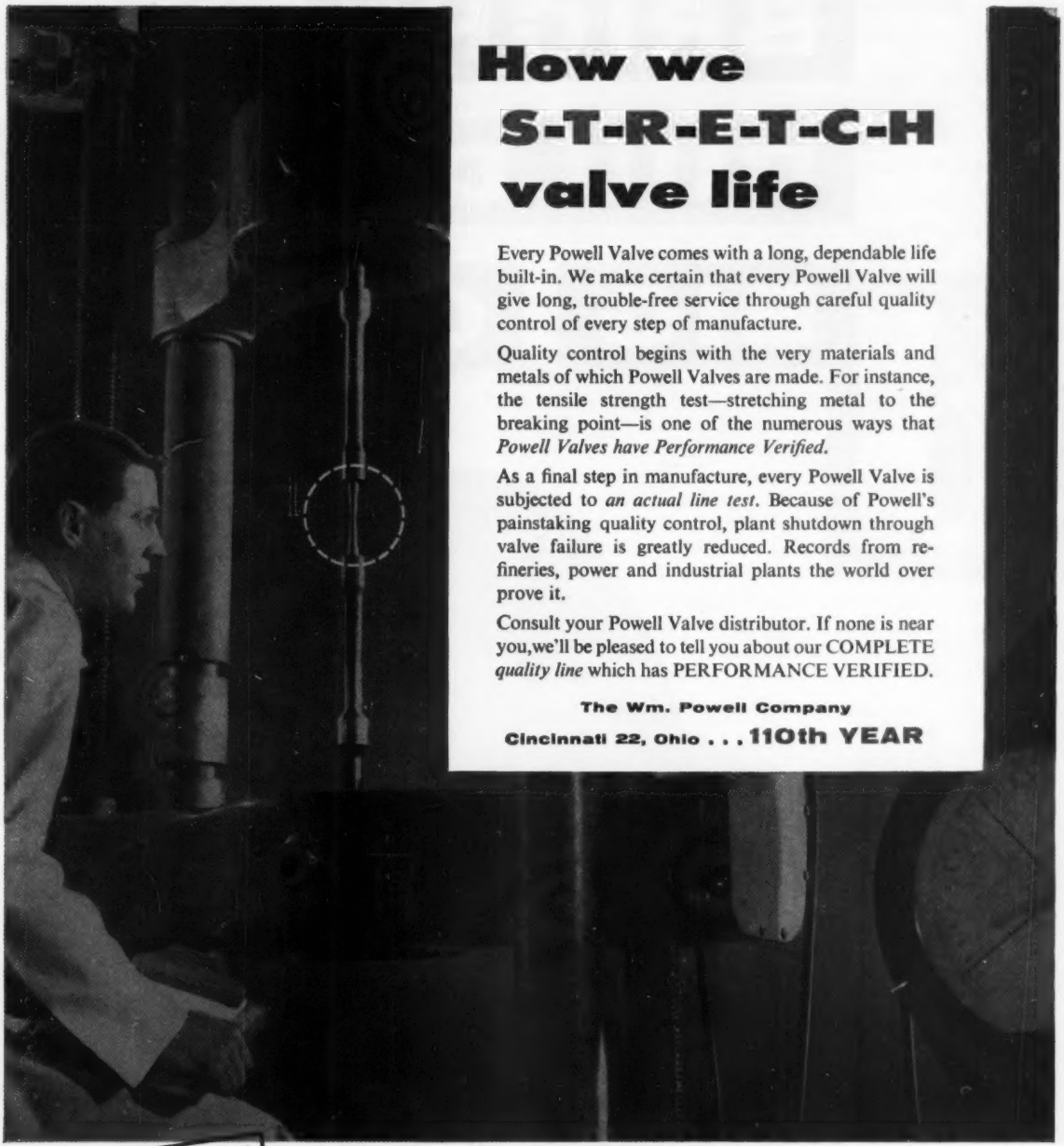
Epperson and Dunlap[2] showed that this equation applies to lubricating oils to within 2 or 3%. The accompanying plotting paper has been arranged so that it covers viscosities between 5 and 40 centipoises and can thus serve for many lubricating oils. As in the use of logarithmic paper, the range of 5 to 40 may also represent 0.5 to 4, 50 to 400, etc.

To illustrate use, consider the blending of two oils, E and D. The viscosity of oil E is 7.45 centipoises, whereas the viscosity of oil D is 33.9 centipoises. What will be the viscosities of blends that contain 21.0, 38.0, 57.2, and 72.3 mole percentages of oil E? On the 100% line plot 7.45, the viscosity of oil E, and on the 0% line plot 33.9, the viscosity of oil D. Connect the two points with a straight line and read off the desired values, as noted with the percentage errors on the chart.

The data for oils E and D and their blends are taken from the paper by Epperson and Dunlap.[2]

REFERENCES

1. Kendall and Monroe, *J. Am. Chem. Soc.*, 39, 1787 (1917).
2. Epperson and Dunlap, *Ind. Eng. Chem.*, 24, 1369 (1932).



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Cincinnati 22, Ohio . . . 110th YEAR

PERFORMANCE PV VERIFIED

FIG. 2475—Stainless Steel O.S.&Y. Globe Valve For 150 Pounds W.P.

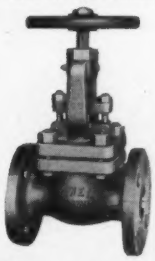


FIG. 1559—150-Pound Steel Lubricated Plug Valve. Sizes 1″ to 4″.

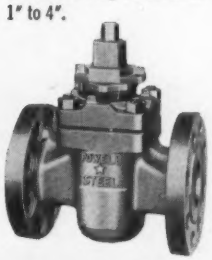
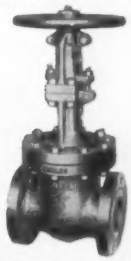


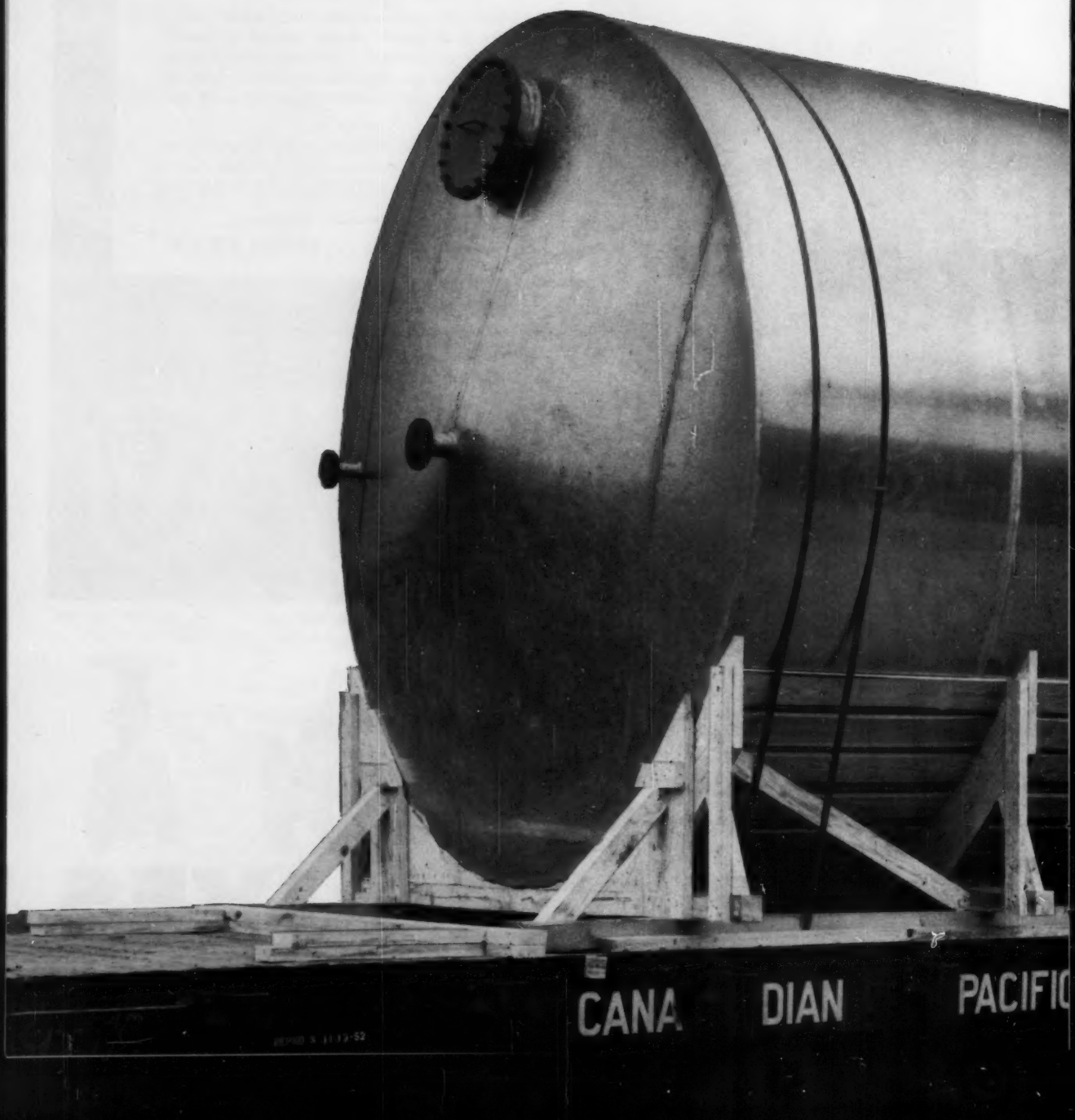
FIG. 3003—Steel Gate Valve For 300 Pounds W.S.P.



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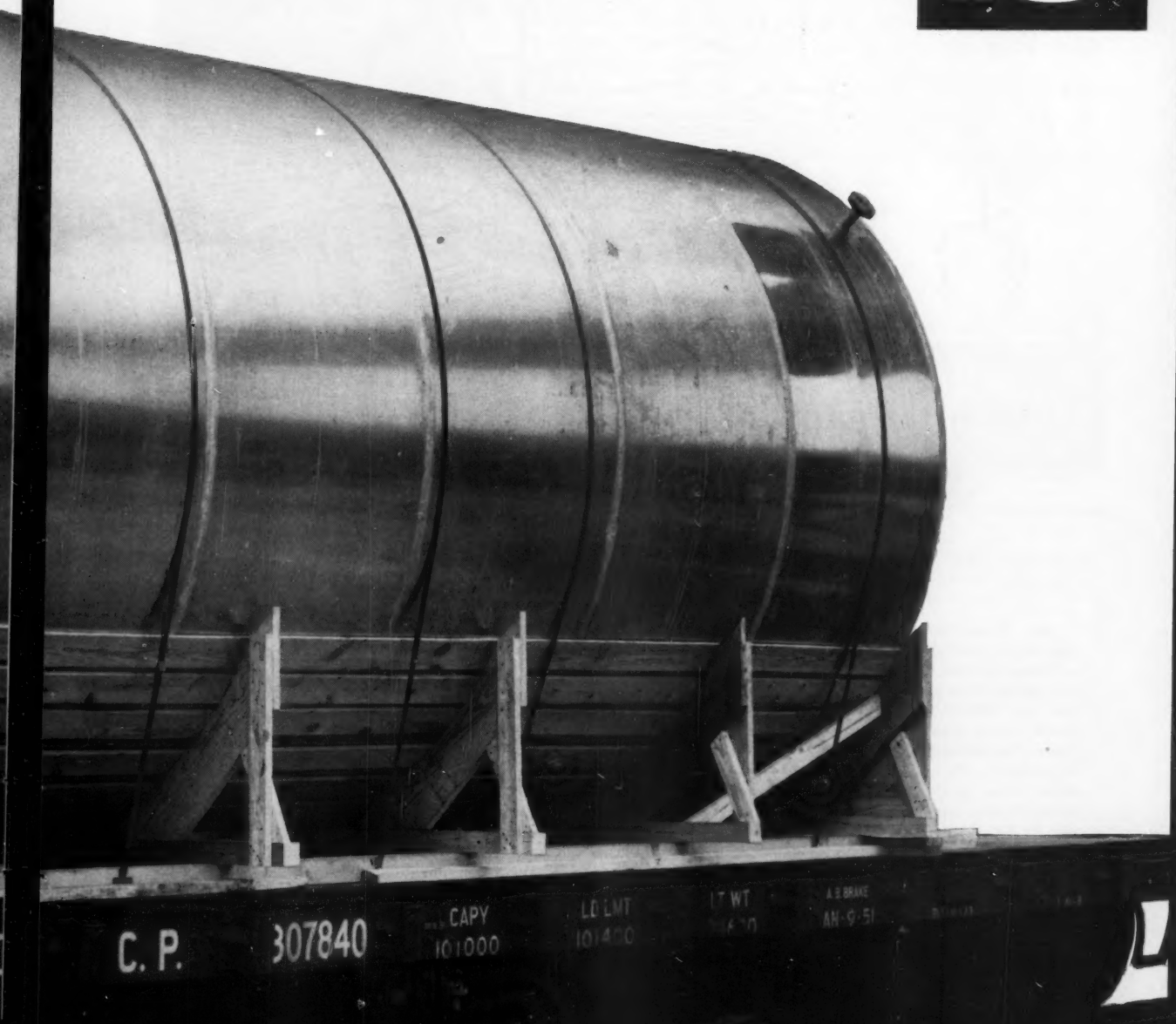


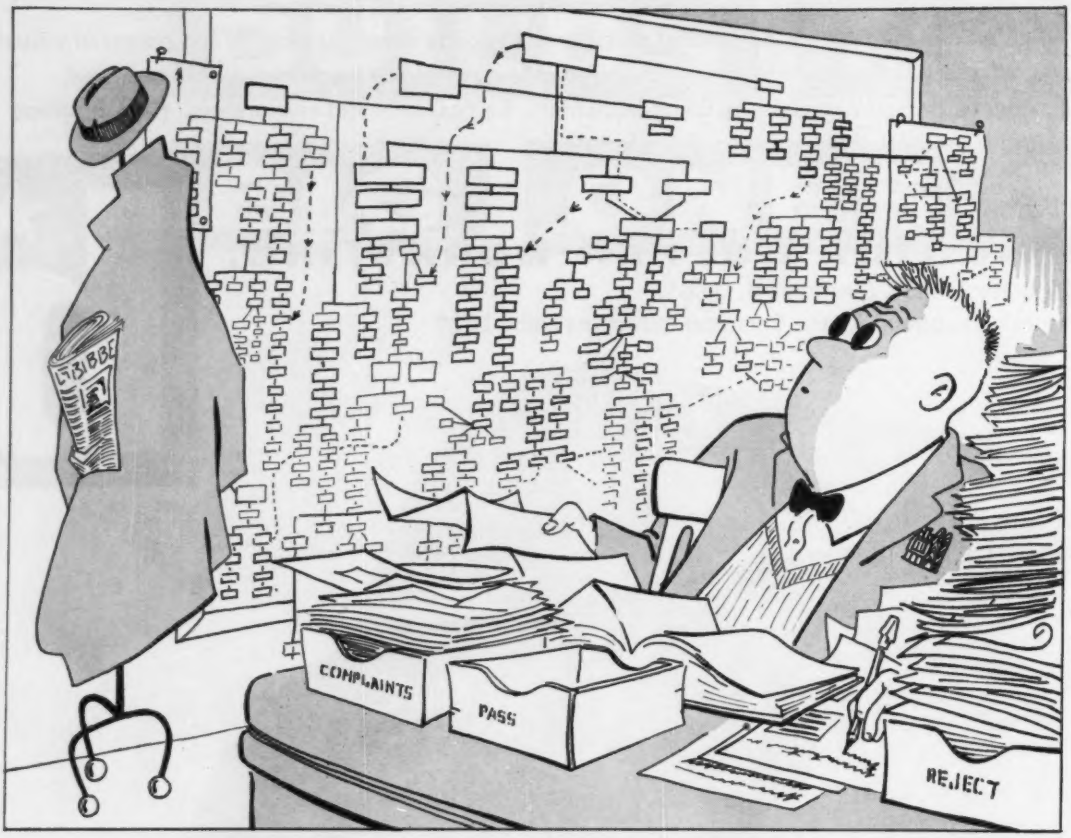
and delivers them on time. This tank is one of two built by Brighton for the Forest Products Chemical Co., Memphis, Tennessee. Fabricated of 3S aluminum, it has a capacity of 17,000 gallons and is used to store acetic acid.

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How to Organize for Top Performance

- **Set definite objectives in all vital areas.**
- **Analyze these objectives three ways.**
- **Watch the best structure take form.**

Any chemical engineer who's had the problem of setting up a group of men to do a specific job knows how vexing a task it can be. Rarely will the group break down naturally into the proper organizational structure to achieve its ends. Somebody always has to sit down with the problem and dope out who's going to do what, when and how; and then he has to puzzle out how to keep track of what gets done, when and how well.

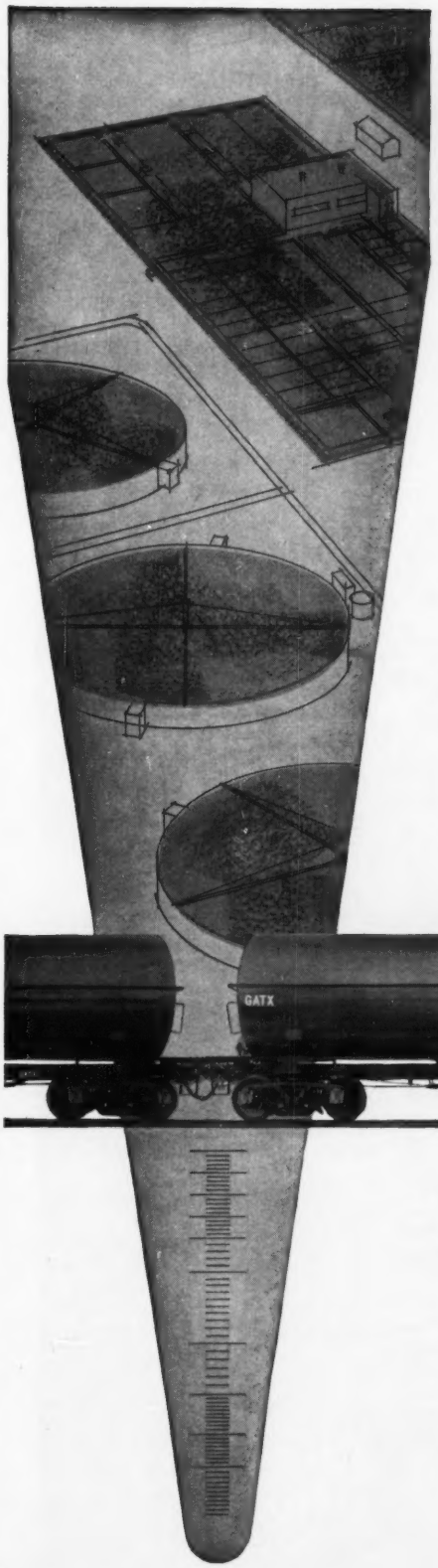
In short, somebody has to organize.

The problem of organizing a group of people to do a job is nearly as old as mankind and many solutions have been proposed over the years. Recent studies, however, have given management experts a new insight into the problem and new principles have been developed and tried. They all add up to a workable method for you to use if the problem ever comes your way—whether you have to set up a research task force, an engineering group, a plant department or an entire company.

Bypassing the traditional thinking of "organization theory," the new approach tailors a structure to meet an organizing need from the beginning, instead of bending and contorting a "traditional" structure to a new need. It helps the organizer answer his two most important questions: What structure is needed; how should it be built.

Use a Workable Way

But most valuable of all, it's practical. As many who've been exposed to traditional organiza-



CHLORINE

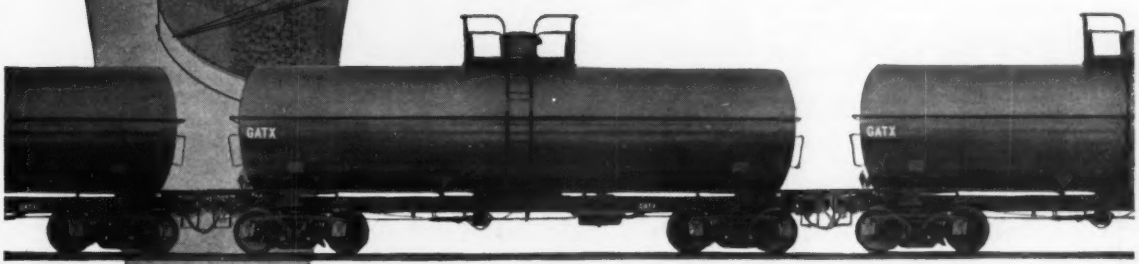
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tion theory know, it's difficult to reduce to practice.

For instance, the traditional method of organizing stresses the logical grouping of activities. But when is a grouping logical? In your company is it logical to lump the cost accountants with the accounting department or should they come under the production superintendent who has prime responsibility for production costs?

And even if an activity does fit into a logical grouping as comfortably as your foot slips into your slipper, how do you know whether it's needed at all? Perhaps it should be completely left out of the organization.

You run into the same difficulties when you try to spell out the duties and the limits of authority for each position.

The organizer who relies on hunches and guesses to structure his group invariably gets a poor performance for his reward. And if the group ever does align itself properly, it's only after a costly and agonizing period of trial and error.

Start From the Goals

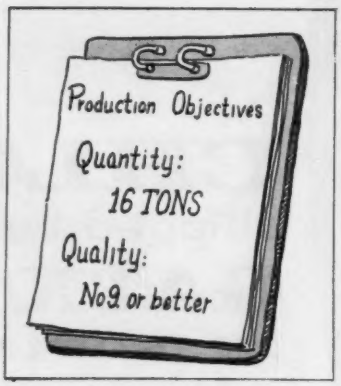
Before you can even begin to know who does what, when and how, you have to have a very clear idea of what you're trying to accomplish. Objectives must be thought through and set down. Then they should be analyzed in terms of

- Activities which will be needed to attain them.
- Decisions which must be made to perform the needed activities properly.
- Relationships which must be successfully maintained to promote peak performance and to enable it to be measured.

At first blush this looks like a pretty imposing job, one that's better left to major companies like GE or DuPont but hardly worth bothering about in a single department or a small group. Actually, the need for proper organization is the same, and in a small unit this process of organizing can often be done in a few hours on a few sheets of paper.

Set Visible, Tangible Objectives

Prime job of the organizer



Set specific objectives.

is to develop a clear statement of specific objectives. Since these limit the size and scope of all activities of the unit, as well as determine who decides what and who reports to whom, this is also the organizer's most vital—and always his toughest—job.

Unless his unit is very small, its task very specific and its time of existance very limited, it will need more than one objective. An organization needs an objective in every area in which its performance directly and vitally affects its survival and prosperity. And these objectives must be visible and tangible—and therefore attainable in a practical way—to its members.

For example: A research group should have carefully thought out objectives in such areas as:

- Quality and quantity of its output.
- Use of physical, financial and manpower resources.
- Performance, development and attitudes of each researcher and helper.
- Public and social responsibilities.

Every one of these areas puts its imprint on the organization's survival and prosperity in both the long and short term, hence each needs a real and tangible objective.

How to Set Objectives

There's really only one way to set these objectives. Once the various areas have been roped off, you have to decide what constitutes top performance in each and what can be used to measure it.

For instance, quality and quantity of research could possibly be reckoned in terms of patents per researcher per year and the objective set at, say, 1.3 patents/man/yr. This automatically supplies a yardstick to the group and to each man in it. And it's a "real" yardstick, one that measure's a man's actual performance and keeps him informed of his progress. (Let's not argue about 1.3 patents/man/yr. being a valid measure of the quality and quantity of research. It's simply a convenient illustration.)

The job of setting objectives for a company unit is relatively easy if the company as a whole has a set of well defined goals in such vital areas as:

- Market standing.
- Innovation—new products or product changes.
- Productivity.
- Physical and financial resources.
- Manager performance and development.
- Worker performance and attitude.
- Public responsibility.

Then for your unit you need only to establish objectives which will best aid the company in attaining its goals.

Who Does What

After defining your goals, your next move is to analyze them to learn what is needed to reach them. This is when your organization structure begins to take shape.

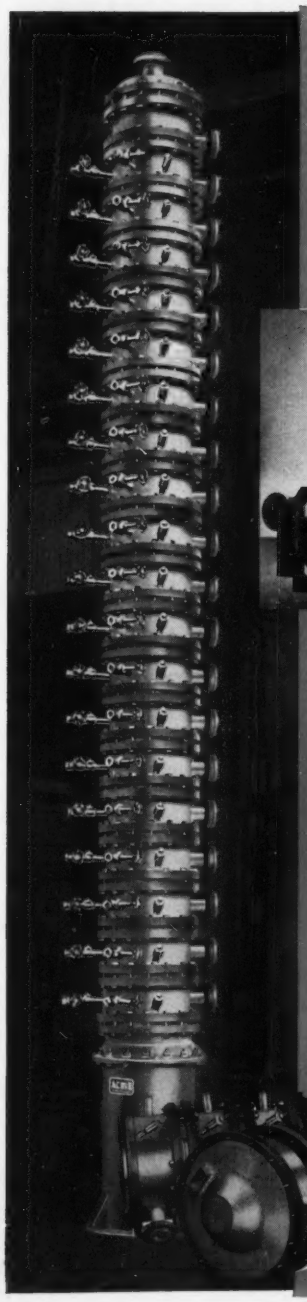
Forget completely about typical functions of groups similar to yours. They may not apply in your case, and even if they do, you may have to emphasize different features. So don't waste your time playing around with them.

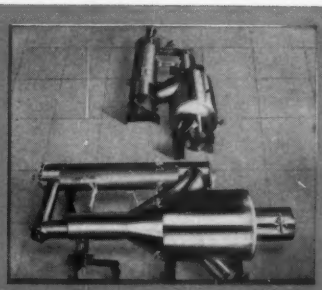
To organize for top performance you have to determine for your own case.

- What work has to be done and how important is it.
- What kinds of work can be grouped.
- What emphasis does each deserve in the light of the objectives to be reached.

VERSATILITY

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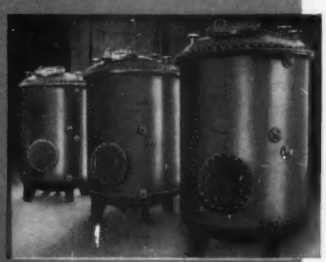




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Make a three-way study.

The objectives themselves dictate what activities are needed. Take the example above where we set an objective of 1.3 patents/man/yr. If this is accepted as a goal then the work to reach it can be laid out. Only a little experience will tell us how many projects must be tackled in a year's time, the size and importance of supporting services which must be furnished, the amount of supervisory effort needed, etc., to enable individual researchers to reach this goal.

Analysis of activities in relation to objectives not only reveals which are needed and which aren't, but it is the only way to rank them logically, according to importance, and to group them according to the nature of their results.

It's a fairly common mistake in industry to subordinate a vital function to a less important one—resulting in its neglect and a drop in over-all performance. Some chemical companies have made this mistake in the past by having research, certainly a function vital to company survival and prosperity in this industry, report to production management rather than top management, where it should have a strong voice.

Who Decides What

The second type of analysis which the organizer has to make to build the proper structure involves decisions.

A searching look at each objective can reveal what decisions are needed to attain it. These usually aren't too difficult to spot, but you are liable to bog down in determining what kind of decision each is and at what level it should be made. And it's even tougher to know the extent to which each activity should participate in each type of decision.

Fortunately, a decision analysis of the objectives usually discloses that the vast majority are typical or routine and readily classified. Of those that don't fit so quickly, ask these questions:

- For how long does it commit the organization and how quickly will a change take effect?
- What impact does it have on the work of other areas and other functions?
- Are qualitative values—principles of conduct or ethics; social, political or religious beliefs; rights of other people and so on—the controlling factors?
- How often must the decision be made?

Obviously any decision which binds the organization in any way for a considerable period and which is difficult to change or revoke deserves high level attention. On the other hand, many engineering and business decisions, though highly complex and involving a lot of money, are almost instantly reversible. These can and should be pushed as far down the line as possible.

Where a decision vitally affects other areas and other functions, however, it should rise to a higher level—unless heads of all affected functions can work in close coordination.

As Far Down As Possible

The important thing here is simply that decisions be made at the lowest level which can fully consider their impact on all functions involved. Setting this level beforehand prevents the too-common spectacle of having decisions go hunting for a home and being passed along until they're past due—or made at a much higher level than necessary.

Something which always tends to push a decision up the line is the number of qualitative factors which enter into it. For instance, negotiating a new labor union contract which affects the rights of a large number of workers and which involves sweeping company commitments is rightly a high level matter. Of course, it is not necessary that a "value" decision always be made at the very top, but its prompt review is always of high level concern.

Finally, an estimate should be made of how often the decision will crop up. Those which are made periodically should be treated differently from those which are rare or unique.

For periodic decisions a high level decision may be needed only once—to set a general rule. When the situation reoccurs, a lower level need only apply the rule.

Take, for example, a decision on whether or not to promote a particular man. After general rules on standards of performance, promotion policy and so on are set, they're simply applied down the line.

The rare decision, on the other hand, needs much more careful thinking through each time it comes up. To decide who makes it involves answering the first three questions above.

In assigning decisions to a job two rules should always be followed: Have it made at the lowest possible level, as close to the scene of action as possible;

Next Month: How You Could Be Treated Better

The success of the engineer unions and the concern they've caused the professional societies is but one symptom of the discontent which observers note brewing among engineers. Salary inequities, recruiting and hiring practices, poor use of trained men, lack of status and recognition—all these are sore spots. In April's You and Your Job an industrial relations expert, now in a top management post, develops and discusses what management should be doing.

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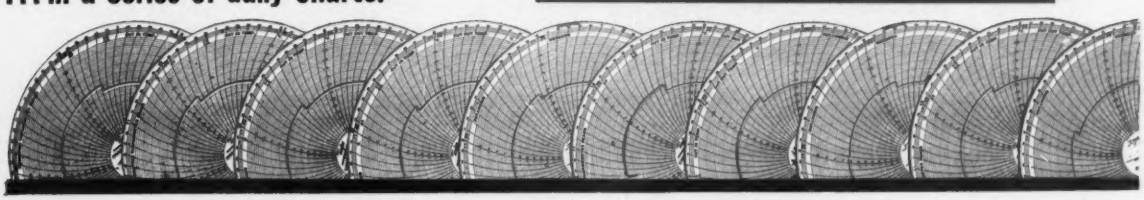
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be sure this level can fully consider all affected activities and objectives.

Who Tells Whom

The final analysis which plans the structure of your organization involves the relationships which must be maintained to insure that each position contributes to and gets from all other positions that which is needed to deliver top performance.

This simply means doping out who works with whom and what each must contribute to the other to attain the desired objectives. To do it you have to take a searching look at each job from three angles. And again the objectives determine what's to be done.

First, consider the upward relations. To the man who fills the job these will be the most important.

Some of the questions to be answered include: Of what larger group or function is this activity a part? What must it contribute to the larger unit to enable it to attain its objectives? How will the larger unit measure the performance of this activity. When you have the answers, your structure will take shape.

Now look into the lateral relationships of each job to determine what each must contribute to other jobs on the same level. At the same time, analyze the job objectives to learn what help and information must come from other jobs.

Finally, examine the relationship of each job with subordinate posts. This, too, flows from the objectives and will be automatically established by your analysis of the upward relationships of the lower level job.

These Are the Major Tools

Activities analysis, decision analysis and relations analysis are your major tools in building an organization structure tailored to your particular objectives and problems. First detailed in a recently published book * by noted industrial consultant and author, Peter F. Drucker, and since enthusiastically accepted by many other management experts, they can help you build or strengthen an organization to deliver top performance.

Try them.

* "The Practice of Management," Harper & Brothers, New York, 1954.

NUCLEAR ENGINEERING . . . *Training Available*

Chemical engineers who've eyed the opportunities in the infant nuclear industry and who've pined for the training to take advantage of them now have plenty of chances to learn more about the field. Books, courses, meetings and seminars now make material available.

A recent AIChE-sponsored survey* lists nearly 40 schools which conduct graduate-level courses in nuclear engineering or reactor technology or in many of the specialized aspects of the field. These courses represent a wide range of approaches—from purely introductory, broad surveys to highly specialized, highly technical sessions.

About half of these schools offer only one course, others give as many as nine.

In addition, various government installations offer instruction to qualified applicants. One of these, Oak Ridge School of Reactor Technology, is now accepting applications for its 1956-57 session. The 50-week training program in reactor engineering here uses both Oak Ridge and university scientists and engineers as faculty.

Sessions don't start until September, but you'll have to hurry to apply. Since classified material is used and consulted in the course, a security check is needed and the deadline for applications is March 12.*

In addition, NUCLEONICS and Armour Research Foundation are co-sponsoring a two-day conference in May.†

For those who can't get away for full time schooling, or who don't live near a night school course, home study courses, too, have been developed. One of these is a 39-lesson course worked up by several university professors and offered by Holliday Co., engineering consultants of Elmhurst, Ill. It covers the field in a broad way, with a minimum of mathematics.

Finally, organizations such as the National Industrial Conference Board and the American Management Association have arranged courses for executive-level groups.

They all spell opportunity to the chemical engineer out to break into the nuclear field. And Atomic Energy Commission Chairman Lewis L. Strauss estimates that there is a current need in this technology for three or four times as many men as are now being trained.

* You can get a copy of the report from the American Institute of Chemical Engineers, 25 West 45th St., New York 36, N. Y., for 50¢.

* You can get forms and other information from the school's director, F. C. VonderLage at P. O. Box P, Oak Ridge, Tenn.

† For information, write L. Reiffel, Armour Research Foundation, 10 West 35th Street, Chicago 16, Ill.

STARTING RATES . . . *Reach New High*

Figures are now coming in on the starting rates which company recruiters are dangling before senior chemical engineering students.

Most chemical company offers seem to fall in the $390-410/mo. range this year, with oil companies prepared to go slightly higher. A few top-notch students command near $450/mo.

Those who pick up a master's or doctorate this spring will also pick up monthly paychecks in the neighborhood of $450 and $600 respectively once they land in industry. Offers vary widely however, depending on the man's background and the company's needs.

There are at least as many company talent scouts clogging college facilities as in prior years and many will bag a lot less than their quotas. But the unhappiest of all will likely be the engineering dean who's looking for a new instructor or assistant professor. Handicapped by campus salary structures, he may even have trouble holding those he has.

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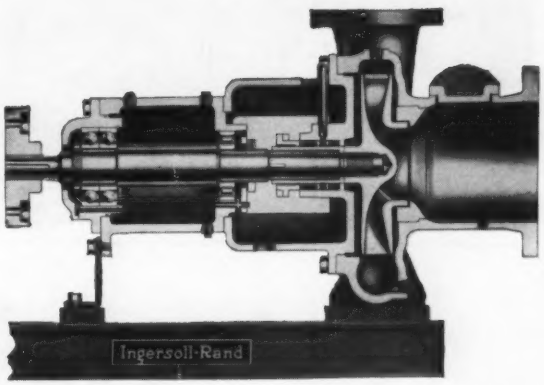
Not just a modified centrifugal pump, the new Ingersoll-Rand Class EL, EM and EH Pumps feature a *radically new* and patented construction which makes them non-clogging, non-vapor-binding, self-venting and self-priming.

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Class 6EH Industrial Liquids Pump





Section through Class 6EH pump, showing the patented construction

These heretofore unattainable performance characteristics result from the unique *diverging* impeller design in which the area at the exit is much greater than at the inlet. Hence the material pumped cannot enter in sufficient quantity to replace the ejected liquid and a vacuum space is created between the blades. Unlike the ordinary centrifugal pump, conversion from velocity to pressure is accomplished in the impeller as well as the casing and the relative velocities are considerably lower. This reduces impeller wear when handling liquids with high solids content.

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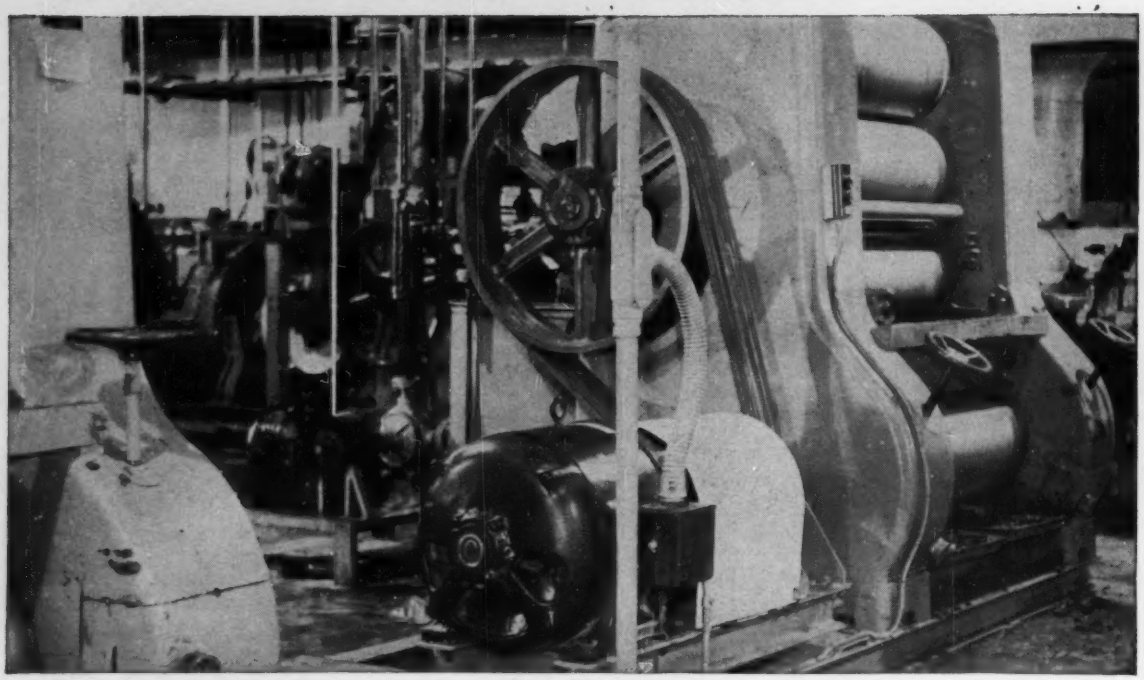
If *you* have a liquid moving problem that's too tough for an ordinary pump, this new I-R Pump offers a practical, low-cost solution. Sizes available for capacities from 200 to 7000 gpm, heads to 225 ft. For complete details, send today for your copy of Bulletin 7325.

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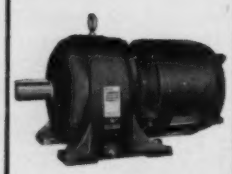


Let each job select

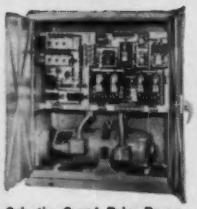
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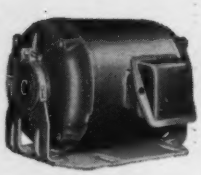
Gearmotors ... ⅛ to 150 H.P. ... parallel and right angle shaft ... "built-in speed to fit your need."



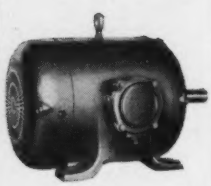
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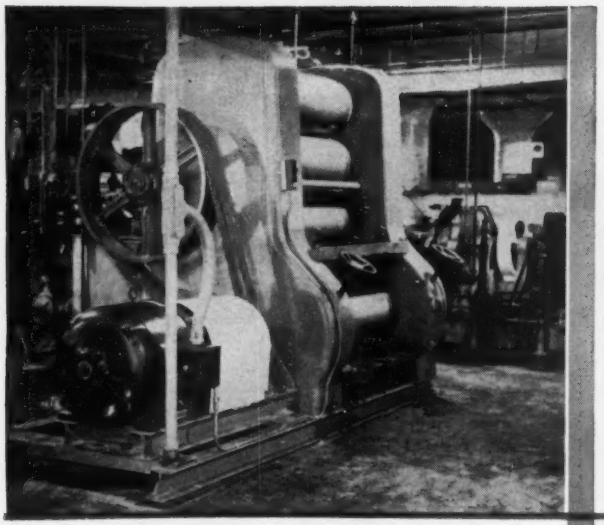
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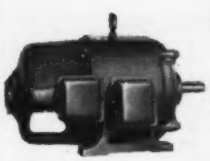
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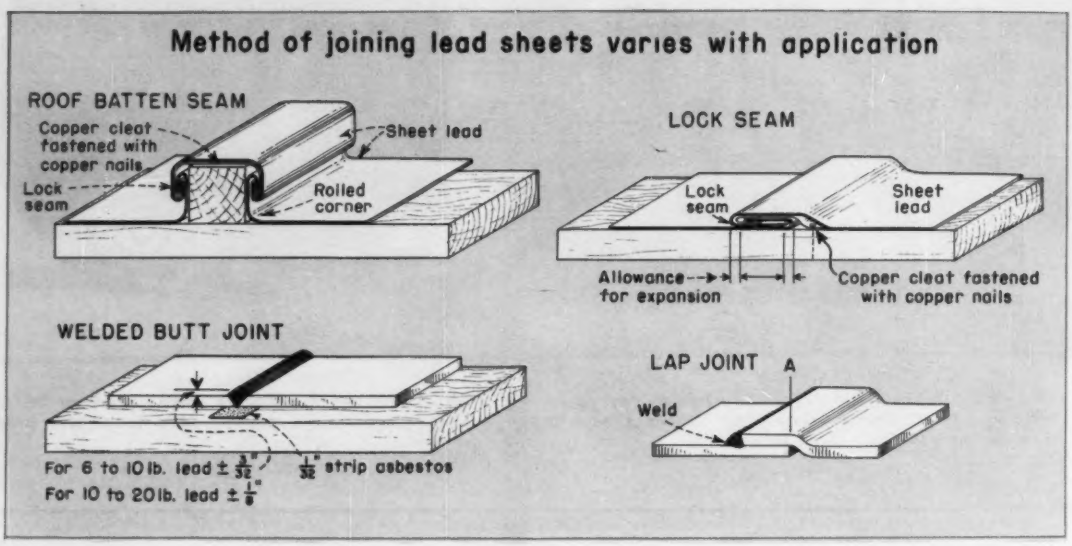
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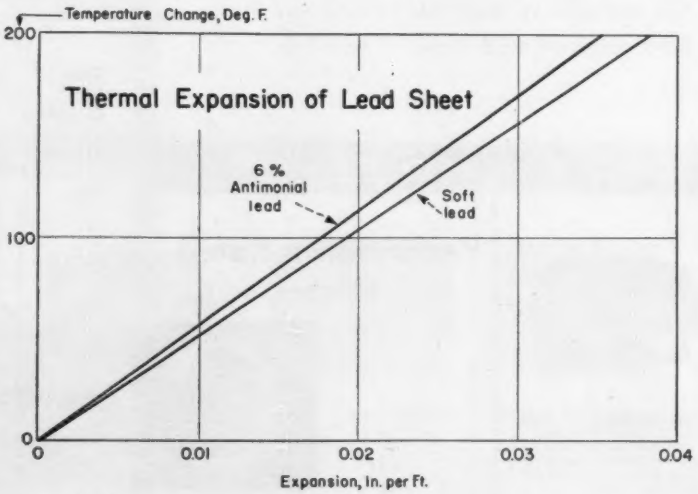
Best Designs for Lead Installations

Recommended practice for joining lead sheets—and the construction of wood stave tanks, launders, towers and flues where lead is involved.

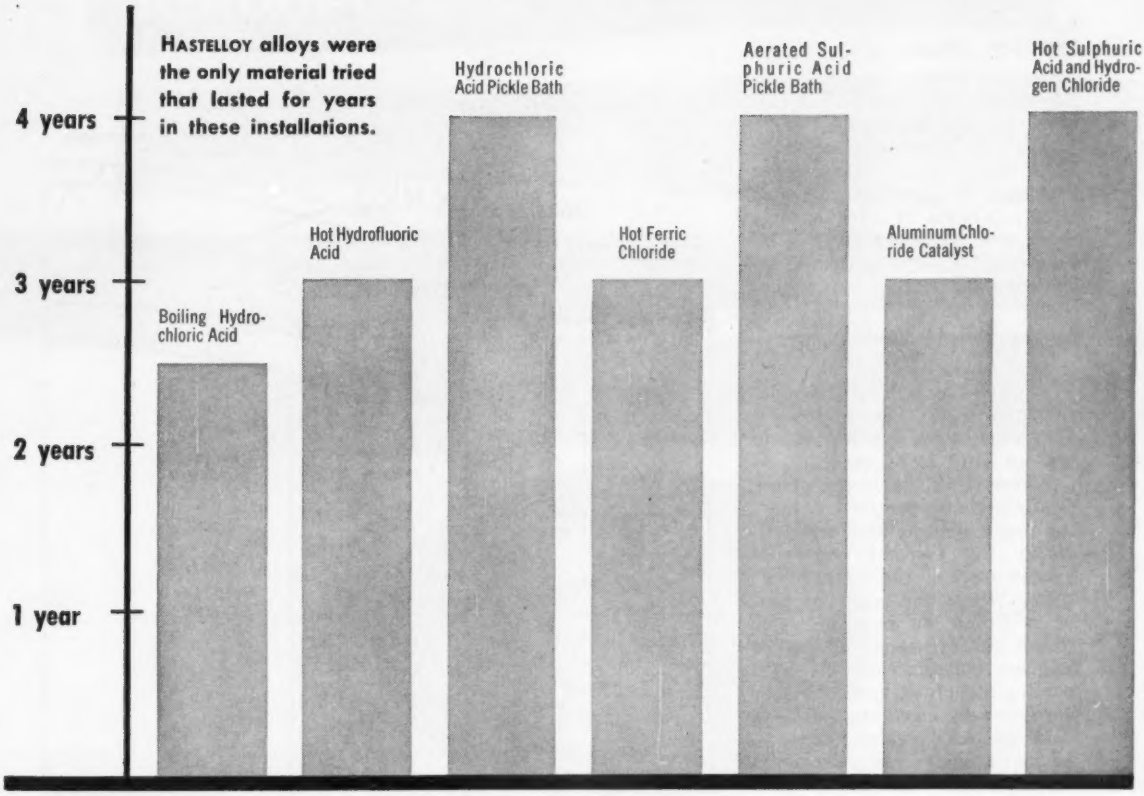
Design of any lead installation requires that considerable thought be given to the details of application, since many failures of lead installations can be traced directly to faulty design or poor application. Generally, these faults may be attributed to:

1. Improper evaluation of the allowable stress—which may be further aggravated by operating at a temperature higher than foreseen when the design was made.
2. Improper provision for expansion and contraction of the lead.

Many design faults in lead work have been proved by bitter



NOTE: *This article contains information from a special company report "Application of Lead and Lead Alloys in the Chemical and Metallurgical Industries" just prepared by the Engineering Division of The Consolidated Mining and Smelting Co., Trail, B. C.—primarily for the edification of their maintenance personnel. It will be of particular interest to design, maintenance, and operating engineers in the chemical industry. Cominco has had extensive experience as a user of lead in corrosive environments. This experience is embodied in the present series of articles, of which this is Part I* —EDITOR.



HASTELLOY Alloys *last for years under severe corrosive conditions*

These graphs were drawn from data on actual installations of HASTELLOY alloys in severe corrosive media. No other material tried lasted more than six months in most of these installations, some considerably less than this. HASTELLOY alloys lasted for years.

Use of HASTELLOY alloys saved time, money, and production time in all the installations. The graphs do not tell the entire story by any means. Some of the parts made of HASTELLOY alloys were still going strong when the data were obtained. In some, corrosion was complicated by abrasion, impact, and the presence of contaminants.

Samples for testing HASTELLOY alloys under actual operating conditions are available without obligation. Just let us know what corrosive conditions are involved. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company Office.

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experience. The trouble has not been readily understood until further recurrences of the same basic faults led to extensive post mortems and practical explanations. Benefits of such experience are incorporated in the following recommendations for good practice.

Joining of Lead Sheets

Lead sheets may be joined by slip seams or welded joints as shown on p. 228. The application under review will determine the type of joint to be used.

Where drainage is the prime requisite (e.g., for roofs), locking seams may be used and provision for thermal expansion may be made in the seams themselves. Where lead takes the form of a lining or covering, and where infiltration of the gas or solution may corrode the supporting structure, locking seams are generally unsatisfactory.

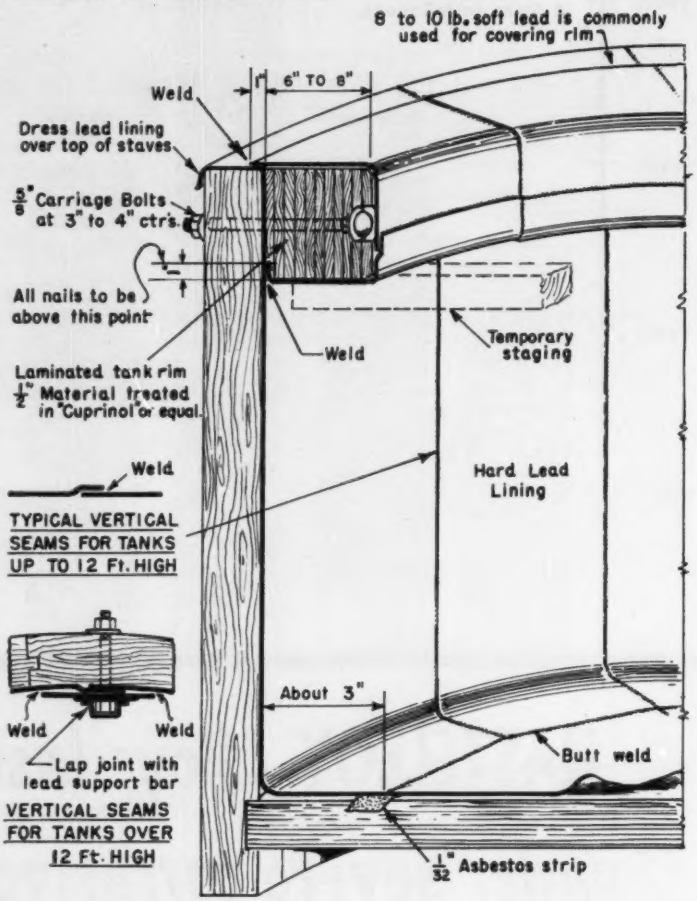
In this case, welded joints are standard construction. Provision for expansion must take another form here. Many authorities recommend lap joints for sheets up to ¼ in. thick (16 lb./sq. ft.).

Experience within The Consolidated Mining and Smelting Co. indicates that there are exceptions to this rule. On horizontal flat surfaces, welded butt joints are preferable where pressure on the sheet (or weight of the lead sheet itself) tends to limit the deformation of the sheet under thermal expansion or contraction to a local area. Any expansion or contraction of the lead sheet will cause the bend at the lap joint to act as an expansion bend, localizing the stress and strain. Experience indicates that the lead will eventually fail along line "A." In this application, butt joints are recommended with full provision for expansion.

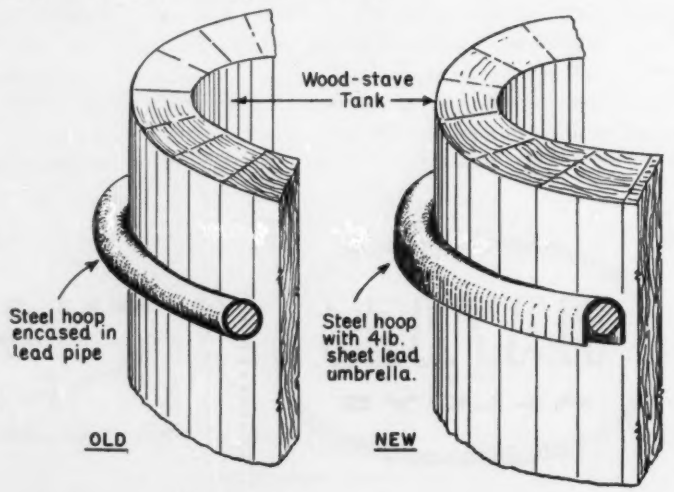
The graph shown on p. 228 facilitates the estimation of the thermal expansion of lead sheet.

Where lead is joined by lock seam construction, it is recommended that a large number of seams be employed—each to take up a small amount of the thermal expansion. With a liberal temperature range allowance, each joint should be limited to a maximum of ¼ in. expansion allowance and preferably less. Where

Lead-lined wood stave tank



Methods of protecting steel hoops



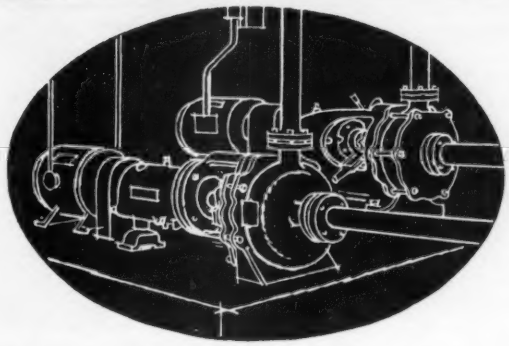
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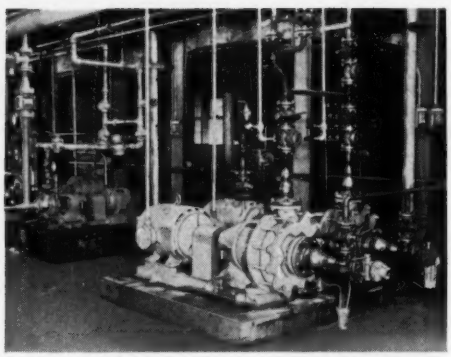
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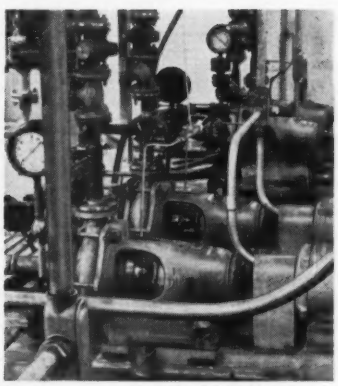
Series H Durcopump



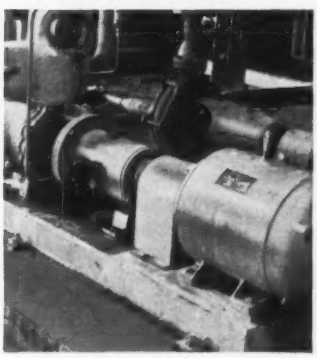
Series R Durcopump



Series R DURCOPUMPS and the DURCO Type F valves in the foreground handle a slurry containing acid insolubles, metal nitrates, and free nitric acid. Another Series R DURCOPUMP (background) handles nitric acid filtrate.



The two Series R DURCOPUMPS and the DURCO Type F valves in the foreground handle scrub liquor with up to 1% nitric acid. The DURCOPUMPS in the rear handle a raffinate slurry containing metal nitrates, acid insolubles, and free nitric acid.



Series H DURCOPUMP (front) handles a nitric and sulfuric acid slurry, specific gravity 1.8-2.0, with a high viscosity at 175° F. Series R DURCOPUMP in the rear is a filter feed pump handling a neutral slurry.

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welded seams are employed, separate expansion bends or joints should be installed at frequent intervals to reduce the take-up in each joint to a practical minimum.

The following are practical design details which have proved themselves in actual practice, and serve to illustrate proper methods of lead installation.

Wood Stave Tanks

Unlined wood stave tanks depend to a large extent on the swelling of the staves for solution tightness. When these tanks are lead lined, there is a tendency for the staves to dry and shrink. The hoops are sometimes drawn up to maintain structural rigidity. Effect on the lead lining is readily apparent. To overcome this weakness, it is recommended that a reinforcing ring be constructed around the top of the tank to maintain the original diameter and shape of the tank.

Unlined wood stave tanks are often suitable for holding a solution without ill effect—except for the corrosive action on the steel hoops. Lead pipe has been used to cover the hoops for protection as shown.

Technically the idea is good, but the lead is often injured and solution may enter the pipe. The solution then lies in the lower concave half of the pipe, often corroding the steel hoop beyond repair before the fracture in the lead pipe is apparent.

It is recommended that lead strips be used in preference to lead pipe. With this construction, the steel hoop is open to inspection at any time. Any leakage through a fracture in the lead will drain away.

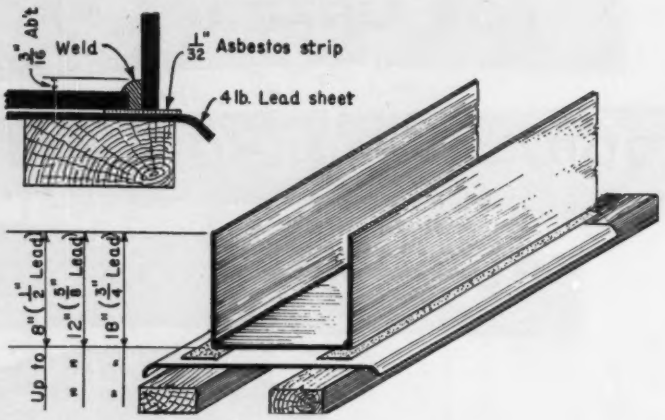
Launders

In the metallurgical and chemical industries, a large number of launders are used to convey solutions by gravity from point to point. Wood launders have been used. Many of these installations have been provided with a lead lining to prevent solution leakage and, where the solution is corrosive, to prevent corrosion of the connectors such as nails and bolts.

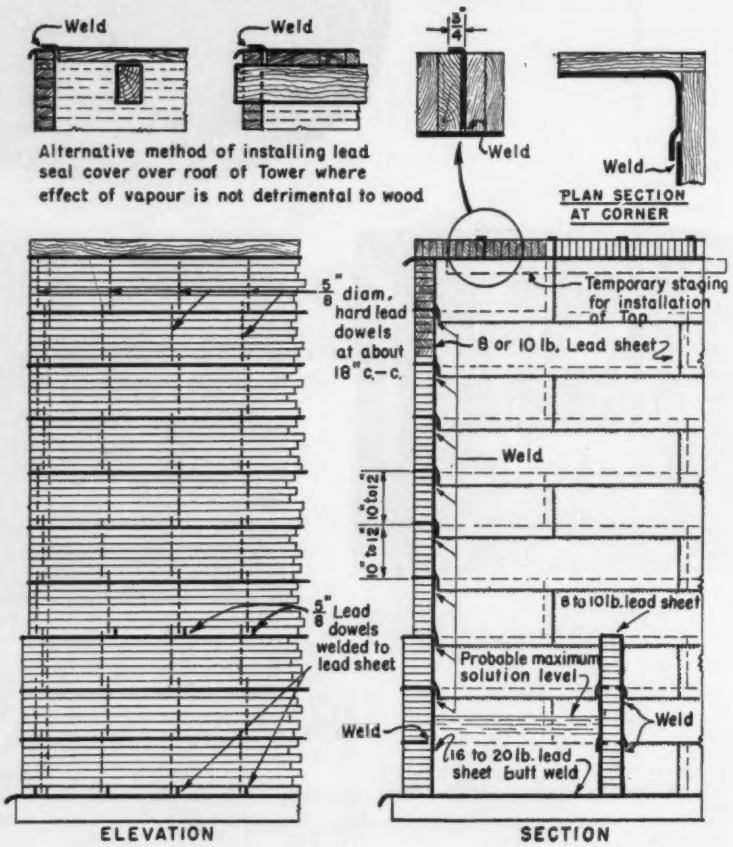
These launders are now being made almost entirely of lead with a minimum of wood or steel supports. This type of construction improves the operation, maintenance, and inspection. Appearance is greatly improved.

Since the lead launder is generally self-supporting with respect to shape, the cost is usually not greatly increased and the serviceability is greatly improved. When the salvage value of the lead is considered, the over-all cost of this type of con-

Recommended launder construction



Recommended tower construction



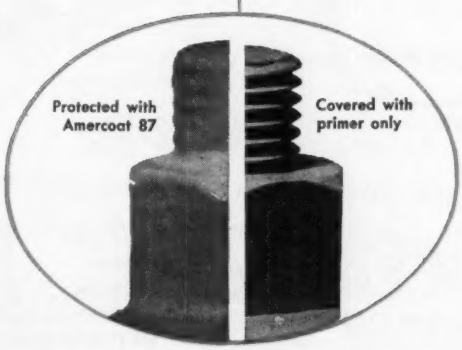
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struction may be lower than that of the lead-lined wood.

Towers and Flues

It is often good economics to build towers and flues of laminated wood construction, and line these structures with lead. Some typical details of this type of construction are shown in the drawings of recommended tower construction and recommended flue construction.

NACE Service Award

Aaron Wachter, Shell Development Co., Emeryville, Calif., has been given the 1955 Outstanding Service Award of Western Region, National Association of Corrosion Engineers. Dr. Wachter, immediate past president of NACE and long active in the association in administrative and technical capacities, received the award at Western Region's Fifth Annual Corrosion Conference Banquet on November 17. The corrosion conference was held in San Francisco, Calif.

Metal Powders Data At a Glance

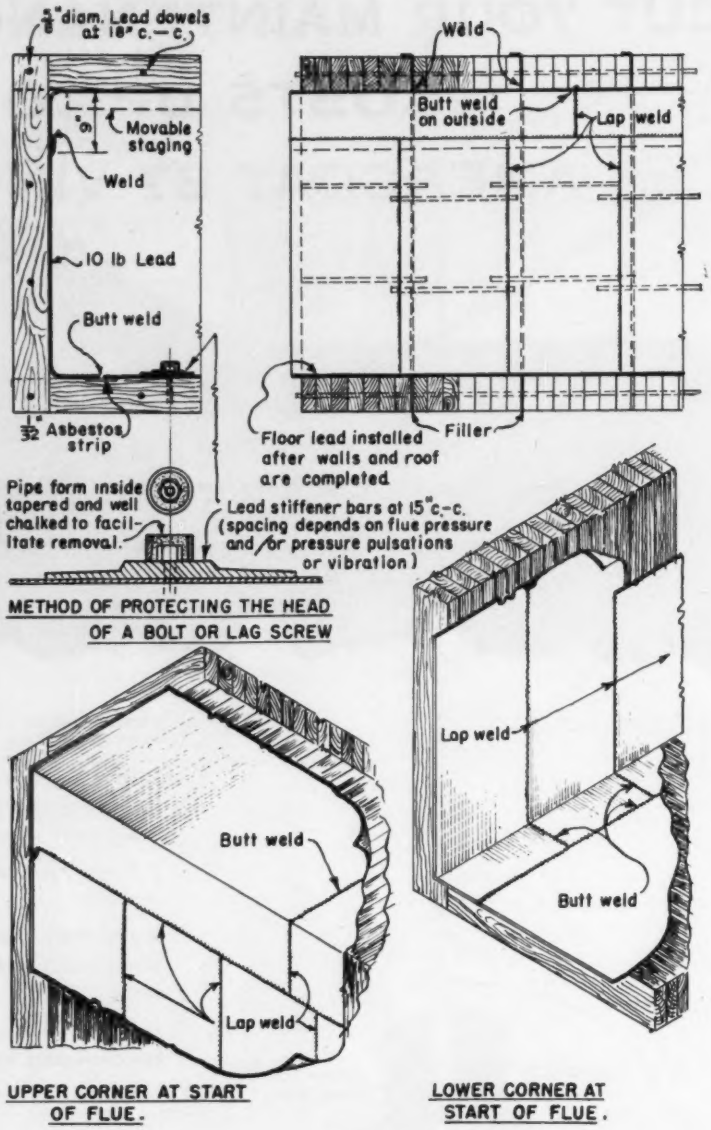
The Metal Powder Assn. has just made available a new data sheet listing and correlating all of the commercially available standards, specifications and other references on metal powders and metal powder products.

Designated data sheet no. 4 and titled "Standards, Specifications and References for Metal Powders and Metal Powder Products," the 4-page publication cross-references standards, specifications and other data published by the American Society for Testing Materials, Metal Powder Association, Society of Automotive Engineers and federal agencies, including the military.

The material is grouped according to publications pertaining to metal powders, metal powder bearings, metal powder structural parts, electronic cores, electrical contacts and others, the latter devoted chiefly to cemented carbides. Official designations are listed, along with pertinent differences between standards issued by different organizations but based on the same subject.

Directions are also given for obtaining copies of the standards and specifications listed, a service that can save much time particularly when trying to locate military specifications. Copies of data sheet no. 4 are available free from the Metal Powder Association, 420 Lexington Ave., New York 17, N. Y.

Recommended flue construction



NEXT MONTH

LEAD DESIGNS—II

See next month's Corrosion Forum for Part II of Best Designs for Lead Installations. Here you will find recommended practice for the design of circular flues, lead-covered floors, piping, etc. as it applies to chemical plant operations.

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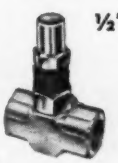
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For *heavy loads* requiring extra high capacity steam traps

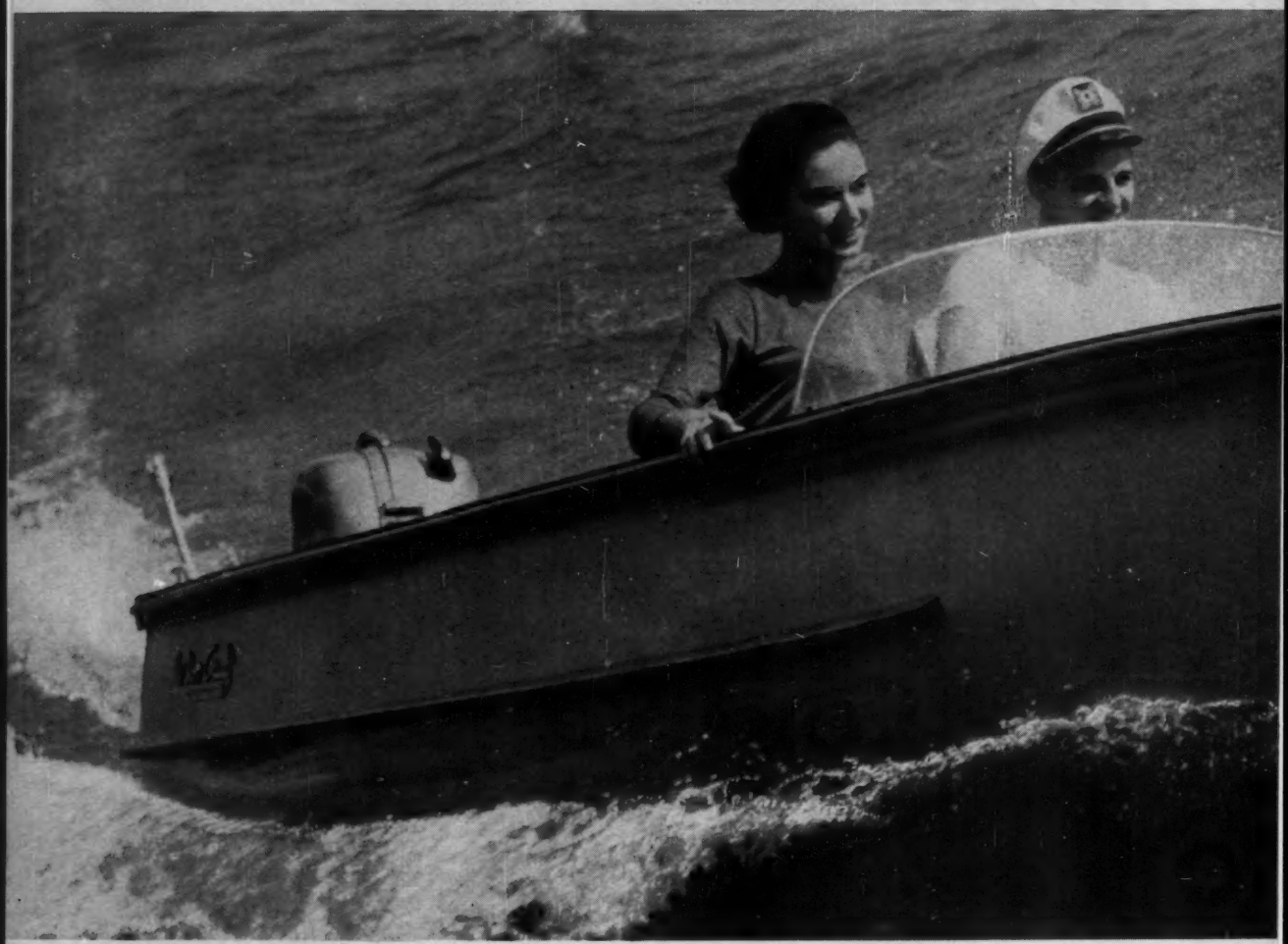


INTEGRAL-STRAINER HIGH PRESSURE TRAP
For *high pressures, high temperatures.* (Flanged or welding connections.)



YARWAY IMPULSE® STEAM TRAP
OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

Test boat demonstrates of Versamid*-epoxy

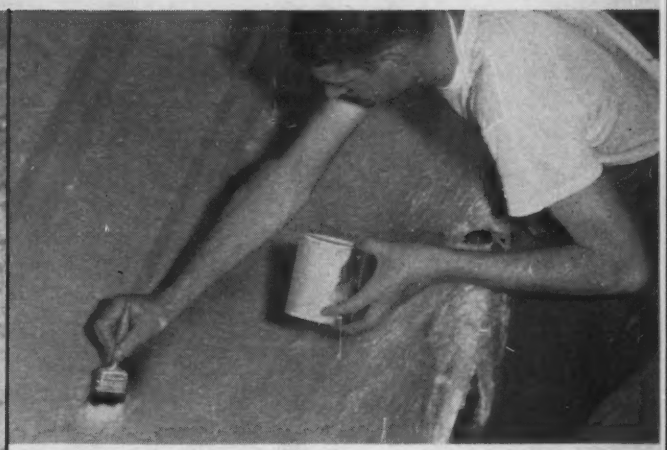


No fear of delamination here! Versamid-epoxy alloys adhere to glass fabric or mats, not just surround them. This gives laminates tremendous strength at high or low temperatures. A quick switch from broiling sun to freezing cold won't crack, distort or weaken them in any way. Versamid-epoxy alloys can be pigmented so they don't need paint, but the tough, glossy surface takes paint beautifully if necessary. Laminated products using this alloy show outstanding resistance to abrasion, mechanical impact, thermal shock, moisture, and solvents. Versamid-epoxy alloys can be applied with spray, knife or roller . . . bond to almost any surface with contact pressure only.

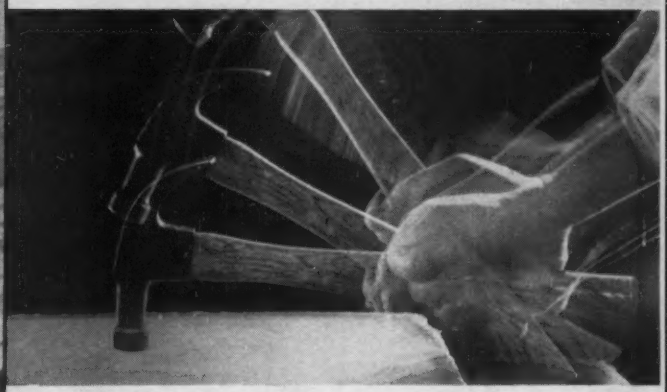
*Investigate **Versamids** the versatile polyamide resins made only by...* **CHEMICAL DIVISION**

exciting properties alloy laminates!





Safety note! Versamid-epoxy alloys emit no toxic or flammable fumes . . . have never been known to cause dermatitis.

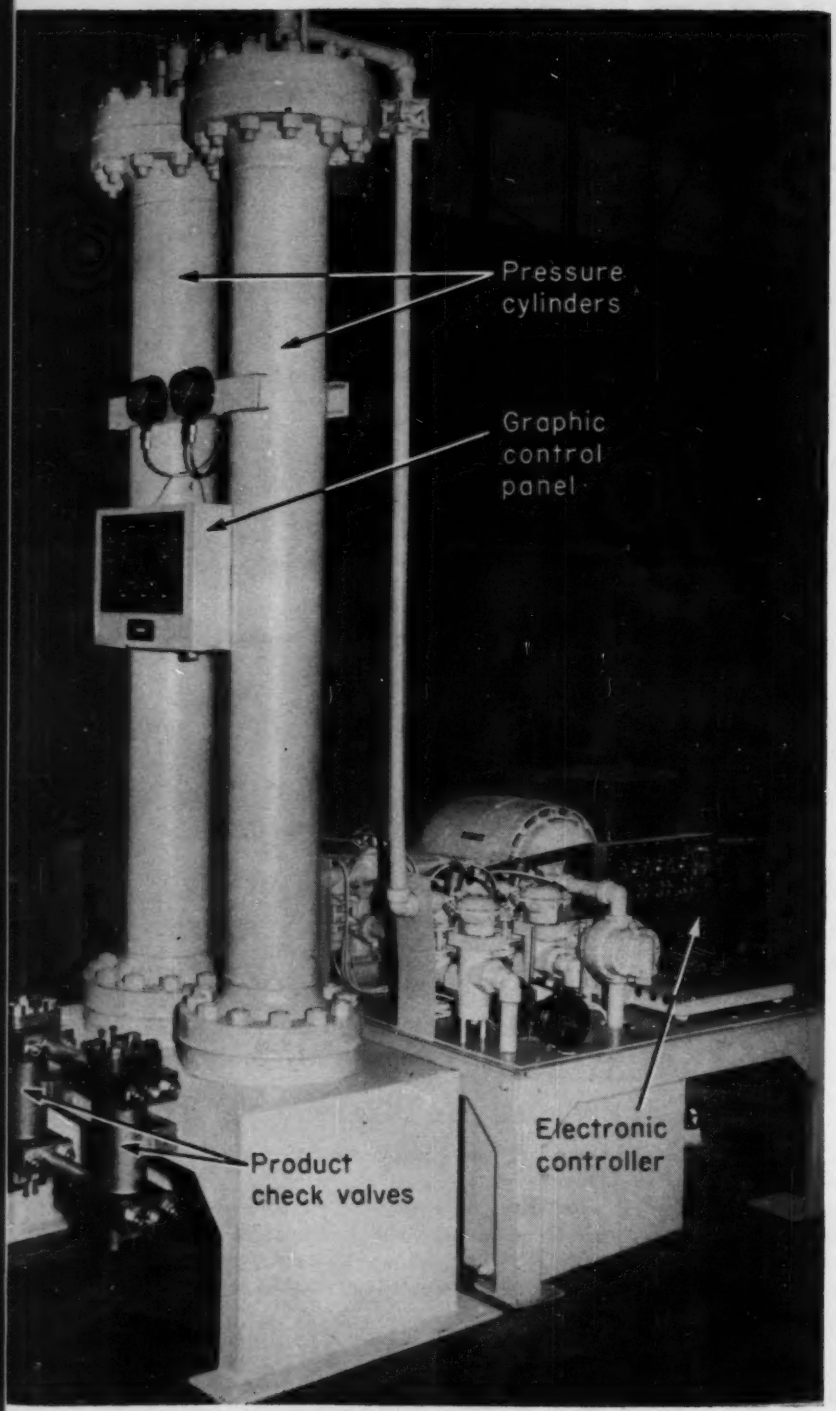


Super tough! Tremendous impact resistance suggests many uses. Takes smashing blows like this without delamination.

How about your ideas? You probably can think of many uses for General Mills Versamids in other glass fiber laminates. Plastic pipe, modern furniture, aircraft components, automobile bodies, swimming pools, and printed circuit bases are among the "naturals." Versamid-epoxy alloys can be formulated to varying degrees of hardness. They cure with or without heat in a relatively short time. Versamid-epoxy alloys can be formulated to hold without "running" on vertical surfaces. Only Versamid polyamide resins make these alloys possible. To learn why, write for Technical Bulletin 11-E. If possible, state production needs so we can be of maximum service.

OF General Mills KANKAKEE, ILLINOIS

Abrasive Wear No Problem for This Pump



Hydraulic liquid displaces process liquid from pressure cylinders. Unit handles abrasive, corrosive slurries up to 2,000 psi.

MAINTENANCE cost slashed more than 95%, initial cost increased only 10-20%—so reports one plant now using the new Hydraulic Pressure Exchange Pump to charge an abrasive, corrosive slurry to high pressure autoclaves. Experience to date indicates this record is more typical than unique.

Reason that pump performs so well under difficult conditions is that it has no plungers, plunger packing or stuffing boxes. And the operating features keep valve wear to a minimum.

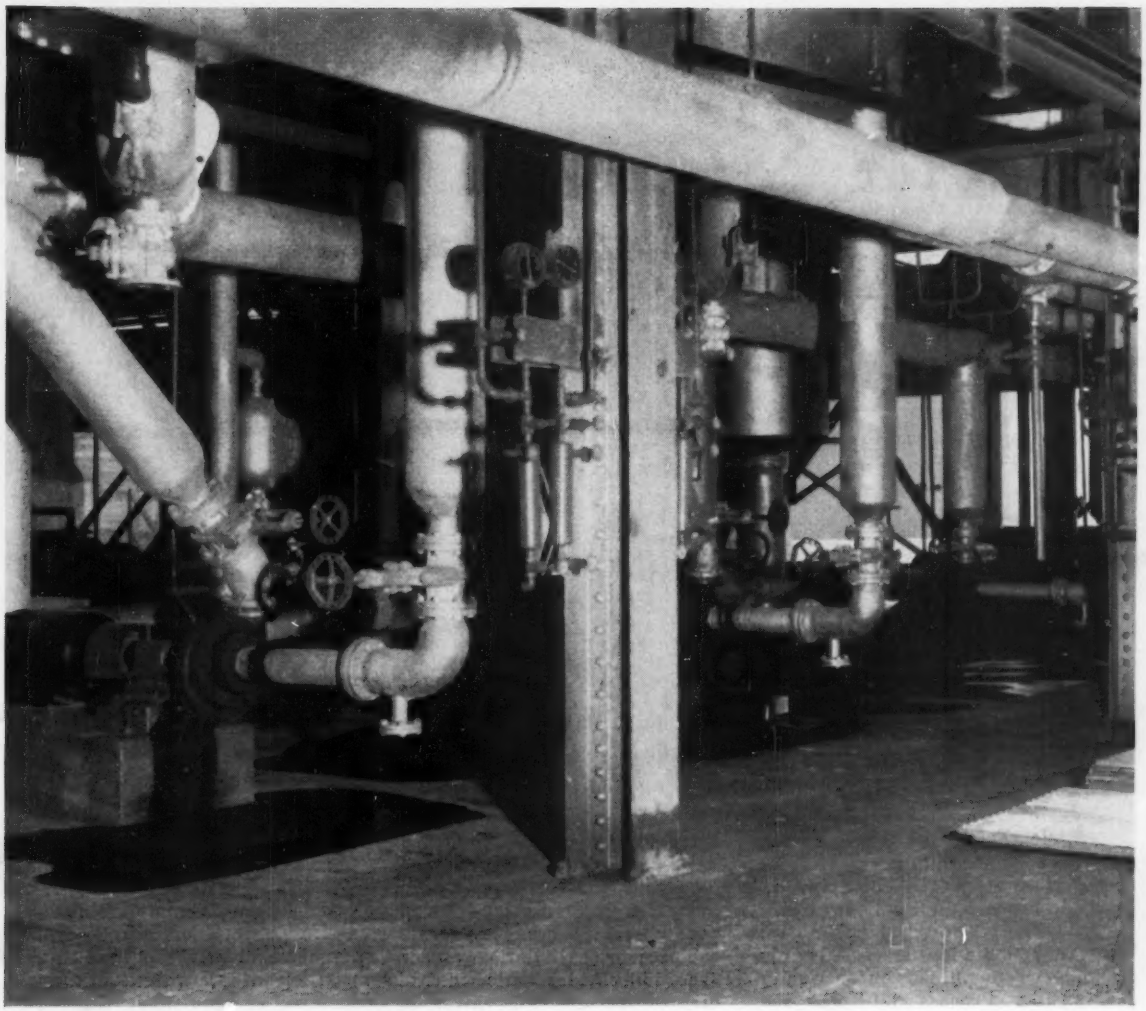
▶ **Where Used**—Pump can handle corrosive and erosive slurries and solutions at elevated temperature and pressure. Single units are available with capacities up to 120 gpm. discharging at 2,000 psi.

Within its range, pump merits consideration where cost of equipment, maintenance and downtime are important. Many jobs of this type now use multistage or high-head centrifugals as an expedient or reciprocating pumps despite high operating costs, it is said.

Where process operating pressure previously has been limited by pump characteristics, the HPE pump enables the process to seek a higher optimum pressure.

▶ **What It Is**—The HPE pump actually has two duplicate pumping systems operating out of phase and interlocked electronically to deliver a uniform, continuous discharge.

Each system expels liquid by exerting pressure on it hydraulically through a membrane. Unlike other pumps that use separating membranes, each of the two systems in the HPE pumps expels up to 15 gal. per



Dependably Yours, too!

The men who know—experienced engineers who specify equipment for handling corrosive liquids—usually pick LaBour pumps.

In the large paper mill shown above, LaBour pumps handle the black liquor evaporating process. The designing engineers knew they could depend on LaBour pumps for continual day-in, day-out service with minimum interruption . . . and so can you.

It's this dependable performance and low maintenance cost that has motivated engineers, for the past 30 years, to specify LaBour pumps for their toughest chemical applications. With this enviable and unequalled background, LaBour pumps are the safe choice for your needs, whenever and whatever they might be.

So, take a tip from the experienced . . . don't lose unnecessary "down time" in your plant due to pump failure. LaBour pumps can be Dependably Yours, too.

ORIGINAL MANUFACTURERS OF THE SELF-PRIMING CENTRIFUGAL PUMP

LABOUR

THE LABOUR COMPANY, INC. • Elkhart, Indiana, U.S.A.

Newsworthy Equipment This Month

Equipment Cost Indexes, p. 240

New Fluids Handling Equipment

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Acid Pump....242A
Globe Valve....242B
Control Valve....242C
Centrifugal Compressor....242D
Vacuum Pump....242E
Dust Filter....244A
Centrifugal Pump....244B
Fluid Agitators....244C
Portable Pump....244D
Sintered Filter....244E
Diaphragm Pump....244F
Pipe Strainers....244G

New Processing Equipment

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Disk Roll Mill....248A
Continuous Disperser....248B
Solids Mixer....248C
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Corrosives Heater....252B
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Photoelectric Analyzer....256C
Selector Switch....256D
Limit Switch....256E
Instrument Enclosure....256F

Page number is also Reader Service code number

For more details, use Reader Service Card

cycle. Result is a slow 15-30 sec. cycle that holds valve wear to an absolute minimum.

▶**How It Works**—Pumping of the process fluid is done within duplicate pressure cylinders. Each cylinder has a flexible sleeve mounted concentrically inside. Process fluid fills the annulus between cylinder and sleeve; space within the sleeve is filled with hydraulic fluid.

During the pressure or discharge part of the cycle, hydraulic oil is forced into the sleeve, distending it to decrease the volume of the annulus. As this volume decreases, the process fluid is forced out of the cylinder through a check valve assembly.

Pressure cylinder is recharged with process fluid for the next cycle by releasing pressure on the hydraulic system. Process fluid under slight pressure then enters the cylinder through another check valve, forcing hydraulic fluid out of the cylinder back into the hydraulic sump.

Each of the two pressure cylinders has a separate hydraulic system actuated through hydraulic pumps driven by a common motor. Through suitable arrangement of diaphragm or solenoid operated two-way valves and check valves, flow of oil from the constant speed pumps can be bypassed back to the reservoir or directed into the pressure cylinder.

A 110-v. electronic control circuit operates the valves in proper sequence to keep the duplicate systems of the pump operating 180 deg. out of phase in order to maintain continuous uniform discharge. All components are interlocked electrically and are completely automatic. A graphic control panel indicates clearly the operating position of all valves at any instant. If sequencing fails, a warning horn sounds, hydraulic bypass valves open and unit stops pumping.

▶**Additional Features** — If actual pumping must be done within toxic, noxious or explosive atmospheres, the hydraulic, electrical and electronic components can be located outside the area. Lengthened hydraulic lines then can be used to connect the hydraulic system to the pressure cylinders within the hazardous area.

Check valve seats can be removed easily and reversed or replaced completely, if necessary. Seats are protected by Stellite or other suitable hard-surfacing material.

Although particularly effective on high pressure applications, the HPE pump is economically feasible for pumping abrasive slurries at low pressure.

▶**Well Proven** — HPE pumps

Equipment Cost Indexes

Industry	Sept. 1955	Dec. 1955
Avg. of all	191.0	196.9
Process Industries		
Cement mfg.	182.8	188.8
Chemical	191.8	198.1
Clay products	177.6	183.4
Glass mfg.	181.2	187.1
Paint mfg.	184.6	190.6
Paper mfg.	184.9	190.9
Petroleum ind.	188.3	194.5
Rubber ind.	190.8	197.0
Process ind. avg.	188.9	194.6
Related Industries		
Elec. power equip.	193.6	199.9
Mining, milling	193.0	199.3
Refrigerating	211.8	219.0
Steam power	180.7	186.6

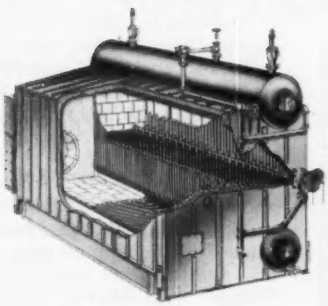
Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; March 1956, pp, 194-5 for annual averages since 1913.

REDUCE YOUR STEAM COSTS THREE WAYS



with the New Foster Wheeler

PACKAGED STEAM GENERATOR



CONSTRUCTION FEATURES

- 36" steam drum and 24" water drum
- Staggered boiler tube arrangements
- Closely spaced waterwall tubes
- Water cooled target wall
- No headers — Low circulation loss
- Light, highly efficient refractory and insulation
- Wide choice of burners and controls
- Baffled steam collector

You save on *first cost* because the FW unit is pre-engineered and shop fabricated from standard parts by the most modern, efficient and cost-saving production methods.

You cut *installation cost*, with a compact, space-saving unit that's shipped completely assembled — all ready to set on a simple foundation — all ready for your fuel, steam and electric connections.

You save *operating cost* all year 'round, because FW Packaged Steam Generators are designed for high sustained efficiency and exceptional ease of inspection and maintenance.

The NEW Foster Wheeler Packaged Steam Generators, in capacities from 10,000 to 46,000 lb/hr, represent the last word in modern steam plant design, reflecting more than 50 years of service to the power generation industry.

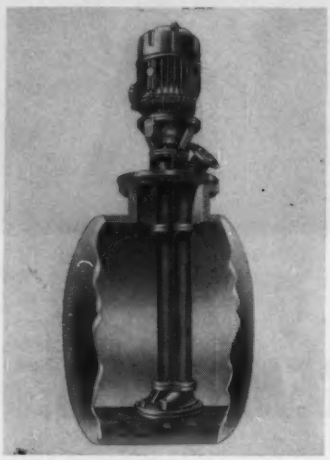
For complete details, send for Bulletin No. PG-55-3.
Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

have undergone complete field testing prior to their introduction to the market at this time. One installation has operated for 1½ yr. handling Ni-Co flotation concentrate, replacing standard high pressure reciprocating pumps used previously and abandoned because of continuous operational failures.

The HPE will handle slurries at concentrations up to 40% solids with particles 60 mesh or finer, without trouble. In short, it will handle products that previously could not be pumped economically. — **Manton-Gaulin Mfg. Co., Inc., 44 Garden St., Everett 49, Mass.** 238A



Acid Pump

Vertical type for submersible duty.

Now available through U. S. representative is the Rheinhutte submersible centrifugal acid pump with vertical shaft. While considered ideal for broad application this unit is especially suited for pumping acids or slimy liquids from containers, tanks, pits, etc.

Pump can be installed with ease, is simple to service. Motor and bearings are protected against destruction should the tank flood. Liquid handled is allowed to flow back to the reservoir through hole in the upper end of the shaft tube. Thus, excessive pressure is not imposed on the gas-proof gland.

Working parts of the pump can be furnished in special grey cast iron, chromium iron or chromium-nickel steel, silicon iron, bronze, antimonial lead and aluminum alloyed with silicon.—**Neumann & Weaver, Inc., P. O. Box 523, 22-12 Raphael St., Fair Lawn, N. J.** 242A

Globe Valve

Unique design eliminates causes of leaky globe valves.

Through a combination of design features the Gyroseal globe valve assures a complete metal-to-metal seal between disk and seat. These features include spinning disk, dual purpose seat and line contact between seat and disk.

Disk is mounted on a spindle against a stainless-steel thrust bearing which assures perfect alignment at closure. At the moment of closure the disk spins rapidly throwing off foreign particles that might catch between disk and seat to cause leakage. The rapid spinning also laps disk and seat to make a complete metal-to-metal contact.

Dual purpose seat consists of throttling seat at top and closure seat at the bottom. By throttling on the upper lip of the seat the closing surfaces are not damaged by inevitable wire drawing.

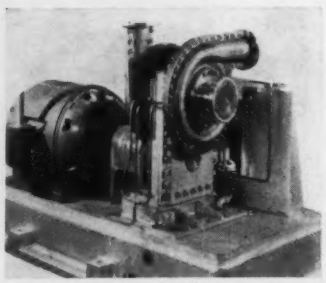
Line contact between seat and disk make tight closure possible with less pressure than needed for area contact—**Gyroseal Valve Div., The Richmond Foundry & Mfg. Co., Inc., Richmond 20, Va.** 242B

Control Valve

Provides one basic valve for all jobs.

Completely new S-3000 Series of standard control valves is claimed to overcome all present-day limitations. Combination of integral positioner, balanced plug, high Cv body, correct spring range, low hysteresis, reversible superstructure and optional tight shutoff is said to make the S-3000 Series the most versatile performer in the control valve field.

In its simplest form this valve is an inexpensive, all-purpose unit. Yet, it can be converted with standard parts into a special valve that provides balanced control with tight shutoff at any temperature and pressure. One basic valve can be used for virtually all process locations; only one spare parts stock need be carried for all valves.—**Hammel-Dahl Co., 175 Post Rd., Warwick Industrial Park, Providence 5, R. I.** 242C



Centrifugal Compressor

Delivers at pressure and flow rates needed for instruments.

New two-stage centrifugal compressor is claimed first that produces pressures needed for instrument air systems at the low flows required. All other centrifugal compressors require considerably higher maximum flow rates in order to compress air to 50 psig. range. Air from new unit is completely oil free.

Compressor delivers flows as low as 350 scfm. at 65 psi. abs. Other models of machine compress from 700 to 2,000 scfm. to the same discharge pressure. These same compressors also are available at reduced discharge pressures. — **Sawyer Bailey Corp., 1559 Niagara St., Buffalo 13, N. Y.** 242D

Vacuum Pump

No contamination of oil by condensable vapors.

New Microvac rotary mechanical vacuum pumps incorporate gas ballasting plus an oil-purging device.

Gas ballasting consists of admitting atmospheric air to

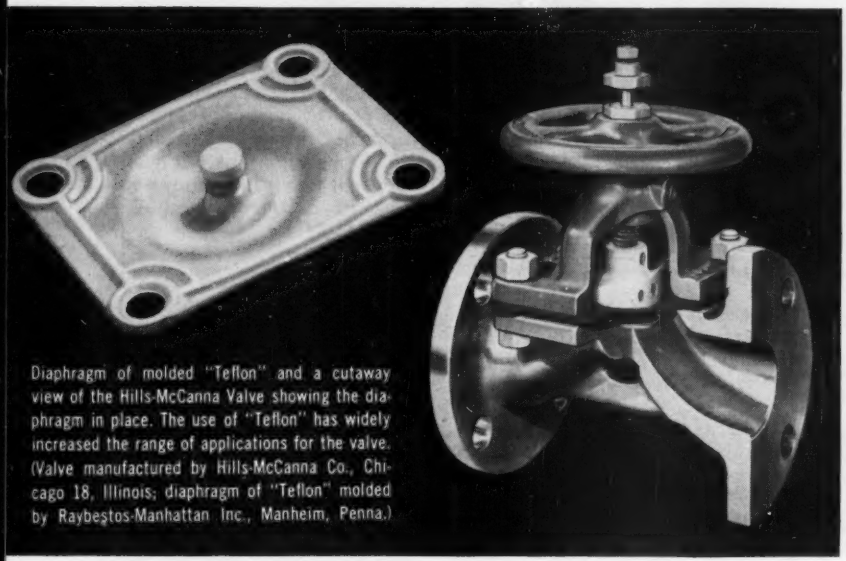
DU PONT

Better Things for Better Living
. . . through Chemistry

CHEMICAL ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS:
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

Diaphragms of Du Pont TEFLON® enable valves to meet new performance standards



Diaphragm of molded "Teflon" and a cutaway view of the Hills-McCanna Valve showing the diaphragm in place. The use of "Teflon" has widely increased the range of applications for the valve. (Valve manufactured by Hills-McCanna Co., Chicago 18, Illinois; diaphragm of "Teflon" molded by Raybestos-Manhattan Inc., Manheim, Penna.)

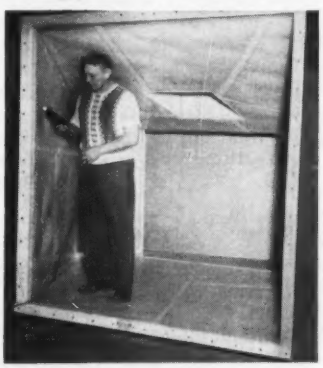
The physical and chemical characteristics of Du Pont's "Teflon" tetrafluoroethylene resin have made possible the valving of many extremely hard to handle fluids. As a diaphragm in the Hills-McCanna valve shown at the left, "Teflon" will handle temperatures up to 400°F., pressures to 100 psi. These characteristics coupled with the remarkable chemical inertness of "Teflon" result in a valve suited to a wide range of operating conditions . . . a valve that can be satisfactorily used for any concentration of mineral or organic acids, alkalies, chlorinated industrial solvents and many other corrosive fluids.

The chemical inertness, heat resistance, resiliency and toughness of "Teflon" recommend its use in gaskets, packings, and component parts of pumps, agitators, mixers, etc. In many applications in the chemical processing industry, "Teflon" is the only material that can be used successfully over any period of time. Since it is unaffected by corrosives, the use of "Teflon" greatly enlarges the range of materials a given piece of equipment can safely handle . . . reduces maintenance costs and downtime, and often permits simplification of design. Complete property and application data on this versatile Du Pont engineering material is available. Mail coupon below.

⅛" lining of ALATHON® protects chemical fume system

"Alathon" polyethylene resin offers many properties of interest to the chemical processing industry. It resists most common chemicals, is light in weight yet strong and flexible, can be readily heat-welded, and is available in the forms of film, sheet, tubing, pipe or molded products.

A typical use of "Alathon" is shown at the right. Here ⅛" sheets of this versatile material are being used to provide a corrosion-resistant lining for a chemical fume system. The sheets are riveted in place and all rivet heads are covered with discs of "Alathon" to protect these heads from corrosion. All seams are heat-welded with butt strap reinforcing. The spark-testing operation shown is a convenient method for checking the quality of the seals. (Lining of "Alathon" manufactured by American Agile Corporation, Bedford, Ohio.)



E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department
Room 253 Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada Limited, P.O. Box 660, Montreal, Quebec

Please send me complete property and application data on Du Pont "Teflon" ☐ and "Alathon" ☐.

I am interested in evaluating these materials for

_____

_____

Name_____

Firm Name_____

Position_____

Type of Business_____

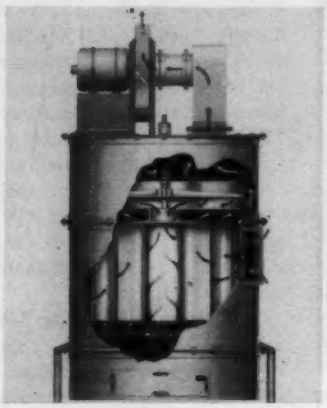
Street Address_____

City_____ State_____

the high pressure side of the pump. This extra mass forces the exhaust valve to open before water vapor and other condensable gases being exhausted have been compressed to the condensation point.

Oil from the reservoir is introduced into the suction side of the piston chamber and in turn is subjected to the gas-ballasting air. Thereby, water in the oil is transformed into vapor.

Combination of gas ballasting and oil purging prevents contamination of the pump oil by condensation of any system vapor.—**F. J. Stokes Machine Co., Inc., 5500 Tabor Rd., Philadelphia 20, Pa.** 242E



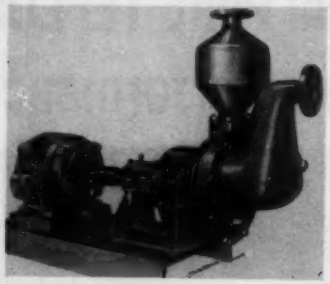
Dust Filter

For flows up to 1,200 cfm., is efficient low-cost unit.

Boasting essentially 100% efficiency, the new Type RJ dust filter cleans dust-laden air and discharges the trapped dirt automatically and continuously.

High efficiency stems from application of the Hersey principle of high-velocity reverse-air cleaning. But the Type RJ filter differs from the usual Hersey type filter because it catches the dust on the outside of the filter sleeves.

Sleeves are arranged in circular fashion. A rotating drum located in the chamber above the sleeves indexes the reverse-air collar over individual sleeves in turn. Mechanism then allows large-diameter plunger in drum to fall short distance forcing surge of reverse air through filter sleeve. Dust falls into clean-out chamber; baffles prevent redeposition of dust on sleeve.—**The Day Co., 810 Third Ave., N. E. Minneapolis 13, Minn.** 244A



Centrifugal Pump

Self-priming for sump, unloading and underground tank duty.

Recently introduced as an integral part of Worthington's standard line of end suction centrifugal pumps is the Type CNGK self-priming pump.

Outstanding feature of the pump is an exclusive removable recirculation port. It allows smaller suction and discharge chambers and faster prime. When impellers are cut down, a longer recirculation port is used so that there is little change in priming time. If severe wear is encountered the port can be replaced with ease.

Type CNGK pump is designed specifically for either packed stuffing box or mechanical seal. It is available in cast iron, bronze, steel, Worthite and combinations of these materials. —**Worthington Corp., Harrison, N. J.** 244B

Fluid Agitators

Integrated packaged units from one manufacturer.

Philadelphia gear reducers for turbine and paddle-type fluid agitator drives have a long performance record among major processors. Now this manufacturer is offering a completely integrated packaged fluid agitator service.

Service is claimed to be unequalled for extensive and specialized designing, engineering, manufacturing, assembly, testing and field servicing facilities devoted exclusively to fluid agitators. Plant manufactures impellers, shafts, drive supports, all gears and reducer housings. Motor, bearings and mechanical seals come from manufacturers specializing in these components. — **Philadelphia Gear Works, Inc., Erie Ave. & G St., Philadelphia, Pa.** 244C

Portable pump transfers acids conveniently and safely from open vessels as well as from standard carboys and drums. Driven by enclosed electric motor, Centri-F pump delivers approximately 6 gpm.—**General Scientific Equipment Co., P. O. Box 6798, Philadelphia 32, Pa.** 244D

Sintered filter removes one micron particles from fluids up to 1,000 F. at differential pressures up to 500 psi. At given flow rate clarifies better at lower differential pressures than others of its type.—**Purolator Products, Inc., Dept. S, Rahway, N. J.** 244E

Diaphragm slurry pump with dual-ball check valve design pumps gently, has positive feed and metering traits. Capacity ranges of available sizes: ½-5 gpm., 1-10 gpm., 2-18 gpm.—**Komline-Sanderson Engineering Corp., Peapack, N. J.** 244F

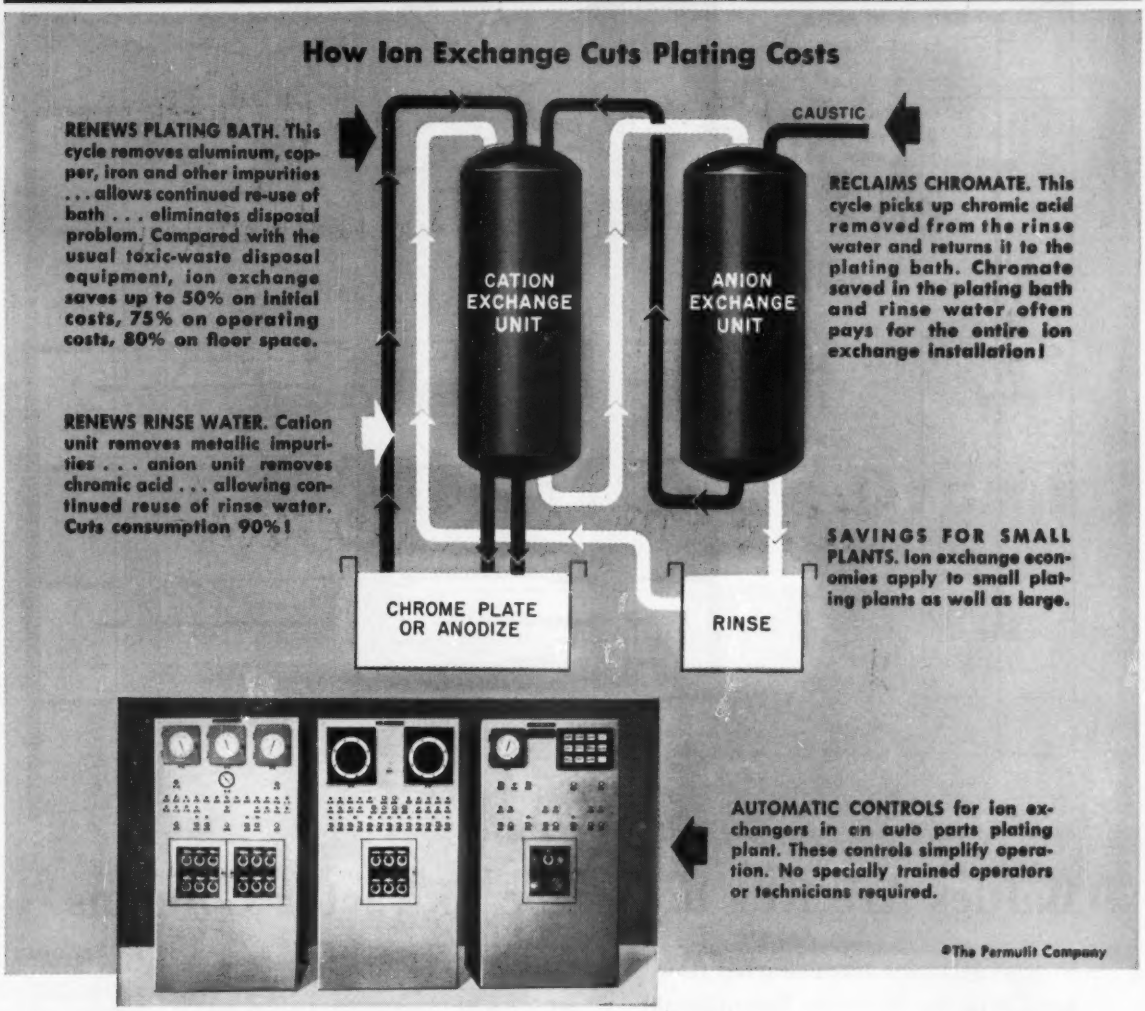
Pipe strainers for oil, gas, air, water and steam lines are cast from carbon-moly steel operate up to 900 psi. and 900 F. Stainless-asbestos gasket between Y-type body and bushing eliminates chance of blowout. — **Armstrong Machine Works, Three Rivers, Mich.** 244G

For More Information . . .



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.

PROCESSES: Ion exchange "swaps" chemicals in solution at high speed . . . purifies, recovers, concentrates, separates. An example:



Ion Exchange Cuts Process Costs

A fast-growing unit process, ion exchange is already a multi-million-a-year business. Here are some of the jobs it's doing now:

• **Water Conditioning** is biggest ion exchange use . . . removing scale-forming hardness for homes, steam boilers . . . softening cooling water so it can be used over and over . . . purifying process water for TV tubes, synthetic fibers . . . reclaiming waste water (e. g. chromate plating rinses).

• **Process applications:** Removing impurities from formaldehyde, glycerin, alcohol, plating baths and other chemicals, also wines, sugar solutions; recovering copper and zinc from rayon plant wastes; concentrating metals in dilute solutions such as plating rinses, mine waters; removing iron from phosphoric acid pickling solutions; producing colloidal silica used in textiles, waxes, foundry molds; making antibiotics, e.g. streptomycin, and other medicinals.

• **Largest manufacturer** of ion exchange equipment, The Permutit Company (N. Y.), got a head start in ion exchange with the natural zeolites first used in water conditioning . . . now manufactures highly efficient synthetic resin ion exchangers of all types. Permutit is the only U. S. producer of both resins and equipment. Making both allows proper "mating" of the two . . . enables Permutit to take responsibility for performance of the entire installation.

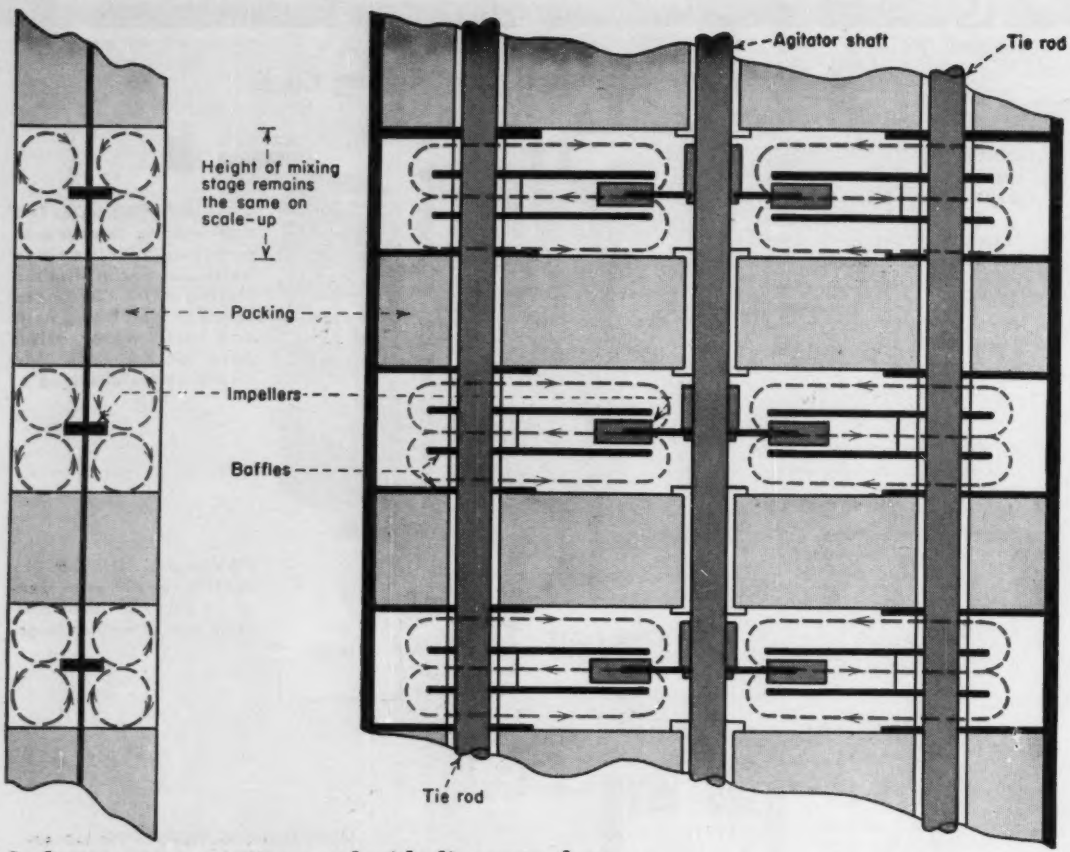
If you have a problem involving the recovery, concentration or separation of chemicals in solution, a Permutit ion exchange process can probably help you. Address: The Permutit Company, Dept. CE-3, 330 West 42nd St., New York 36, N. Y.

PERMUTIT®

rhymes with "compute it"

ION EXCHANGE

for Water Conditioning • Chemical Processing



Scale-up range now increased with discovery that . . .

Baffles Are Key to Larger Extractor Columns

Mixing baffles shorten flow pattern in column to permit larger diameter liquid-liquid extractors with low HETS values. Design promises major cost savings.

Reliable scale-up to larger diameters at much lower final cost is reported for a new internally baffled, multi-stage liquid-liquid extractor (pat. applied for). Whereas, manufacturer's previous design was most practical up to 4-ft. diameter, new design can be scaled up to 12 ft. diameter.

Horizontal baffles in each mixing section restrict flow pattern to relatively short height. Resultant low HETS values make possible the installation of a large number of stages within a single shell.

Amount of packing needed has been cut drastically. Since this is a major expense item much of the cost saving is rooted in this cutback.

Actually, when running a difficult extraction system with high interfacial tension no packing is used; on easier systems with low interfacial tension there is advantage in using packing rather than additional mixing sections.

New design is expected to prove of real value in exploiting the fractional-liquid-extraction technique because a large number of stages can be placed in one unit.

▶**Direct Comparison**—In a recent report before the AIChE at Detroit, E. G. Scheibel of York Process Equipment Corp. gave a direct comparison between unbaffled and baffled extractors. Using a 12-in. unbaffled column on an acetic acid-methyl isobutyl ketone-water system gave a minimum observed HETS of 9.2 in.; the same size baffled column gives a minimum HETS of 3 in. on this system.

On a difficult system such as o-xylene-water an unbaffled extractor gives a minimum observed HETS of 15 in. while the baffled unit has an HETS value of only 4 in.

Based on Dr. Scheibel's report the ratio of HETS to column diameter runs about 1:4. However, the larger baffled columns now under construction



Here's why you can't beat

CONTINENTAL Fibre Drums


Drums designed for automatic handling, quick filling


Extensive research constantly improves our fibre drums


Special containers give your product extra protection


Fast supply service from conveniently-located plants

Lightweight, sturdy packaging *plus* service–that's what you get when you buy Continental fibre drums. We make available expert engineering facilities, and you have your choice of more than 60 sizes, 17 colors, 16 inks. For safe shipment, you can't beat Continental fibre drums. For packaging advice, you can't beat Continental service. Why not call on us soon?

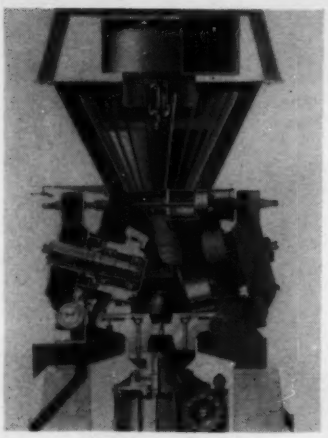
CONTINENTAL CAN COMPANY
FIBRE DRUM DIVISION • VAN WERT, OHIO
New York • Philadelphia • Pittsburgh
Tonawanda • Cleveland • Chicago • Atlanta • St. Louis
San Francisco • Los Angeles • Eau Claire • Boston

are designed for a ratio of these values considerably below 1:4.

▶**Look At Difference**—Normal flow pattern in an unbaffled column is shown on the left. How the mixing height of the first picture is retained at the larger diameter by using horizontal baffles is depicted on the right.

Horizontal baffles have been positioned to direct liquid flow across the column. They can be spaced to give any desired flow pattern without regard to dimensional similarity. Flow through the column is a function of probability effect and difference in densities between phases. When packing is used the phases coalesce in the sections interspersed between the mixing sections.

During development of the new design, stage efficiencies were correlated as a function of power input per unit volume of solvent throughout and the ratio of the flow rate of the dispersed phase to that of the continuous phases.—**York Process Equipment Corp., 4 Central Ave., West Orange, N. J.** 246A



Disk Roll Mill

Grinds relatively soft minerals to 20-325 mesh.

With over 800 mills now operating, the German-developed Loesche mill has been improved and added to the Hardinge line. Known in the U. S. as the Disk Roll Mill it is particularly suited for grinding relatively soft minerals. Featuring the lowest maintenance and power cost for mills of this type it can also grind economically certain abrasive materials which cannot be ground in other roller type mills.

Feed to the mill is ground between two rolls and a horizontal disk or table which rotates at relatively slow speed.

One major improvement is use of the Gyrotor air classifier to remove fine product from the table discharge and circulate oversize for further grinding. A second major change is substitution of pneumatic pressure control for former spring loading of the rolls. In addition to holding uniform pressure the pneumatic system permits unloading the rolls so that the machine can clear itself of overload.—**Hardinge Co., Inc., 240 Arch St., York, Pa.** 248A

Continuous Disperser

Based on successful batch machine.

The new Kinetic Reaktor is an adaptation of the well-proven Kady mill designed to handle a continuous flow of material. It is recommended for use where chemical reactions are promoted best by agitation, where the most rapid dispersion of reagents is required, or where agitation appears more profitable for inducing a reaction than high temperatures or pressures.

Kinetic Reaktor utilizes sudden release of kinetic energy to achieve unusually high degree of agitation. Particles moving rapidly in closed circular path suddenly escape through slot and hurtle against slot wall converting kinetic energy into work.—**Kinetic Dispersion Corp., 95 Botsford Pl., Buffalo 16, N. Y.** 248B

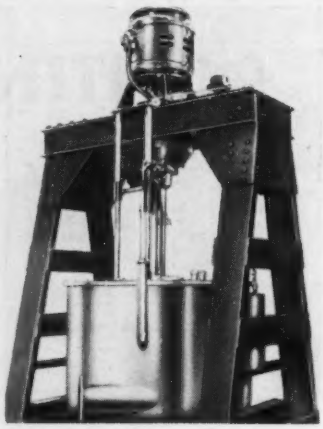
Solids Mixer

Avoids dusting or solids degradation.

Using a unique precessional motion, the Nauta mixer quickly mingles any number of similar or dissimilar dry materials into a uniform mixture. Gentle, positive action mixes solids intimately in any proportions without dusting or degradation.

Mixer can wet dry solids with small quantities of liquid. Also, it dissolves solids in liquid media. For heating or cooling during mixing, the body can be jacketed.

Mixer has a revolving screw that precesses around the interior of the inverted cone body. As screw revolves and precesses, it circulates material from the bottom to the top of the cone.—**Blaw-Knox Co., Buflovak Equipment Div., 1543 Fillmore Ave., Buffalo 11, N. Y.** 248C



Automatic Centrifugal

Batch type controlled by timer.

Automatic control of the Fletcher vertical, batch-type centrifugal is now available through use of a program timer in conjunction with a two-speed magnetic motor starter and electrically operated air valves. Control can recycle the machine automatically, await manual starting for each cycle or operate machine automatically only on unloading.

Motor starts on slow speed and accelerates to the loading speed. Charge valve opens automatically and closes at specified time, if solids concentration is uniform. When slurry concentration varies, charge valve is closed by a cake thickness detector.

Washing, acceleration, spinning, braking and unloading are all controlled by the master timer. When a basket valve is



No matter how you do it, get word to Morton for help in solving any salt problem

The Morton Salt Company offers fast help from salt specialists—at no cost to you. And mighty valuable help it can be, too, for a Morton Consulting Engineer in your area can be dispatched to your plant. He can counsel you on the best grade, or grades, of salt for your particular operation. He can help you plan a new water softening system; he also can help you expand or modernize your brine installation.

The man from Morton is an expert when it comes to salt, and he's backed by the services of chemists and salt scientists at Morton's ultra-modern salt research laboratory. Best of all, these services don't cost you a cent—and they may well save you hundreds of dollars.

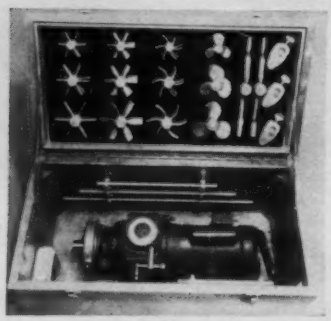
Whatever your salt needs are, Morton can fill them promptly and economically. Morton produces many grades of salt for use by the chemical industry. Only Morton has nine strategically located plants to serve you. And only Morton can offer fast delivery from a bag to a trainload, at favorable prices and freight, *anywhere* in the country.

Sending notes in bottles is recommended only if yours is an off-shore installation. The best way to get help, of course, is to write or wire.

MORTON SALT COMPANY
INDUSTRIAL DIVISION
Dept. CE-3, 120 So. La Salle Street,
Chicago 3, Illinois



needed an air-operated cone valve can be supplied to function automatically, permitting discharge of the cake.—**Fletcher Works, Inc. Glenwood Ave. & Second St., Philadelphia 40, Pa.** 248D



Experimental Agitator

Designed for bench and pilot scale study of mixing problems.

Announcement of the Model ELB experimental agitator marks the first time that small scale fluid agitation can be done without loss of geometric, kinematic or dynamic similitude. Scale-up accuracy is increased.

Specially designed drive with constant speed motor and variable speed transmission offers output from 0 to 1,100 rpm. Twenty-two calibrated impellers in kit are accurate small scale replicas of commercial turbine, propeller and paddle impellers.

Handbook furnished with kit completely reviews fundamentals of fluid agitation, details steps for investigating a mixing problem. Scale-up factors are discussed with the aid of many charts and graphs.—**Chemineer, Inc., 1044 East First St., Dayton 2, Ohio.** 250A

Sodium Disperser

Available as package for pilot work.

Designed around the Cowles Dissolver, two new packaged units are being offered for dispersing sodium in an inert organic medium. The efficient dispersing action of the Cowles impeller has been fully utilized in both the 1,000-2,000 ml. laboratory unit and the 3-7 gal. pilot unit.

Laboratory unit consists of 2-liter flask, metal thermometer, copper coil condenser, dropping funnel, electric heating mantle and 3-in. Cowles Dissolver.

Pilot unit prepares 3-4 gal. of sodium dispersion within 10-20 min. Sodium particle size averages 6-8 microns with 15 micron maximum.—**Morehouse Cowles, Inc., Los Angeles 65, Calif.** 250B

Autoclave

Built with water-cooled drive shaft.

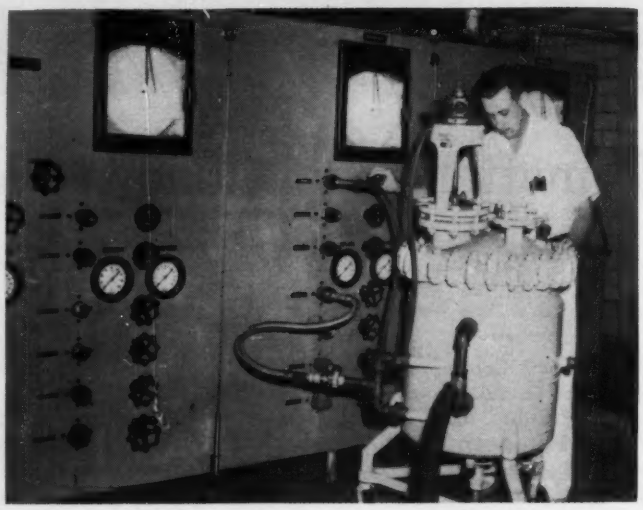
A high-pressure autoclave now is available with a water-cooled drive shaft to lengthen the life of the packing. It can be furnished for pressures from 500 to 30,000 psi. and capacities from 1 liter to 20 gal., is built in stainless steel, Hastalloy, monel or others.

Agitator is designed for all types of catalytic material from gases to solids. Base of autoclave is completely enclosed so that air purge can be used to prevent explosive vapors from contacting heater coils. Motor mounting is accessible for belt take-up and pulley changes. It adjusts easily for pitch and agitator speed.—**High Pressure Equipment Co., Inc., 1222 Linden St., Erie, Pa.** 250C

For More Information . . .

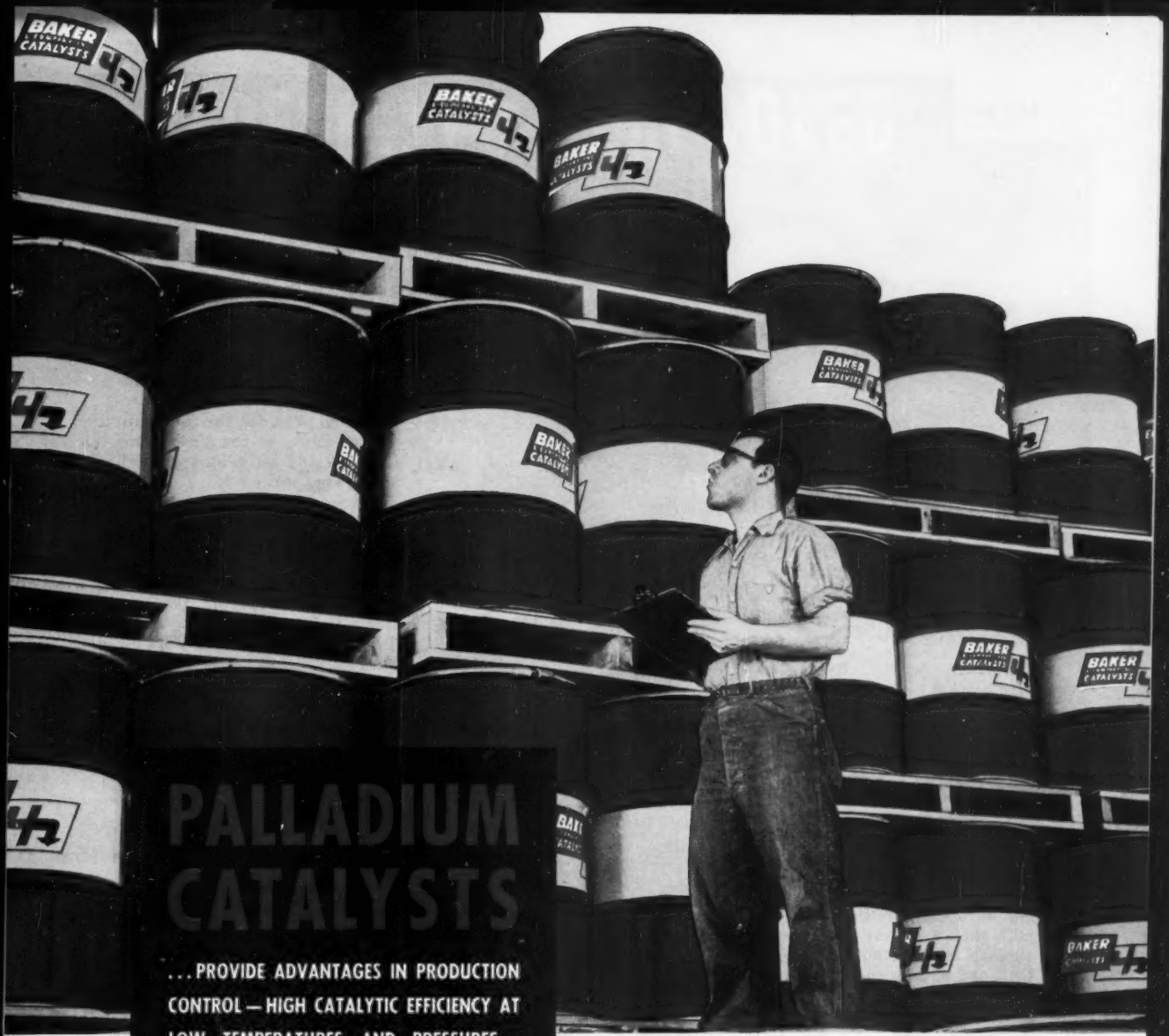


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Centralized Service Facilities for Pilot Plant

Operator Roland Seidel adjusts the speed of air-driven agitator shortly after connecting portable extraction tank to novel service board at Armour Laboratories new pilot plant, Kankakee, Ill. Six available panels provide connections for air, water, steam, vacuum and refrigeration. Unusual degree of operating flexibility results.—The Armour Laboratories, Div. of Armour & Co., Chicago 9, Ill. 250D



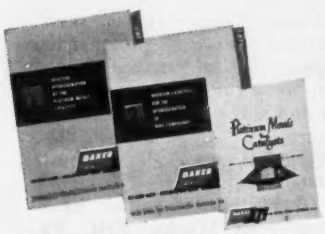
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...PROVIDE ADVANTAGES IN PRODUCTION CONTROL—HIGH CATALYTIC EFFICIENCY AT LOW TEMPERATURES AND PRESSURES—HIGH YIELDS AND LOW COST CATALYSIS

Baker-developed platinum metal catalysts are available promptly, in any required concentration of metal—on the carrier and in the form best suited to your requirements—by the gram for research or by the ton for production.

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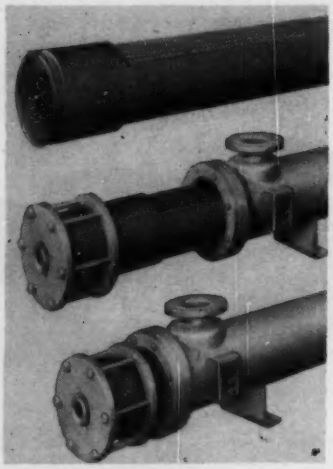


Literature on Platinum Metals Catalysts is available and will be sent at once, upon request.

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THE HUB OF PLATINUM METALS RESEARCH



Heat Exchanger

Built with one-piece impervious graphite bundle.

The Impervite Cross-Bore heat exchanger utilizes the highly efficient heat transfer design having cross-drilled passages in solid blocks of impervious graphite. Equipment is particularly good for applications involving fouling, mechanical shock, high operating pressures and corrosion.

Cross-Bore exchanger has a "one-piece" bundle housed in a standard shell. With this design both shell and tube sides can be cleaned simply and thoroughly. Unit can handle operating pressures in the 150-200 psi. range at temperatures to 340 F.—**Falls Industries, Inc., Aurora Rd., Solon, Ohio.** 252A

Corrosives Heater

Has glass tubes in steel shell.

A new 50 sq. ft. Pyrex brand shell and tube heater has been developed to heat corrosive liquids. Terminating 18 unit months of field testing, manufacturer reports exchanger is extremely economical to operate and maintain. It can heat any corrosive acid, except hydrofluoric, as well as corrosive coke byproduct oils and liquids for pickling and electroplating steel.

Twenty-six ¾-in. thin-wall Pyrex brand glass tubes are mounted inside an 8-in. dia. by 12 ft. steel jacket. Six asbestos baffles support the tube bundle.

Heater has carried heat loads of 975,000 Btu. per hr. Over-all coefficients have been measured up to 175 Btu./hr./sq. ft./deg. F. Maximum operating temperatures are 450 F. at the steam inlet and 200 F. in the glass tubes. Flow capacity is approximately 270 gpm.—**Corning Glass Works, Corning, N. Y.** 252B

Heaters

Now rated for 50% more pressure.

Pressure rating for two styles of header-type, double embossed Platecoil heaters has been raised from 100 to 150 psi. Increase results from improved engineering, factory control and fabrication. Safety factor of 1 to 4 has been retained between maximum operating pressure and rupture pressure.

Platecoils consist of embossed sheets of metal welded together or to a flat companion plate to form channels for passage of heating or cooling media.—**Tranter Mfg., Inc., Lansing 4, Mich.** 252C

Packaged Boiler

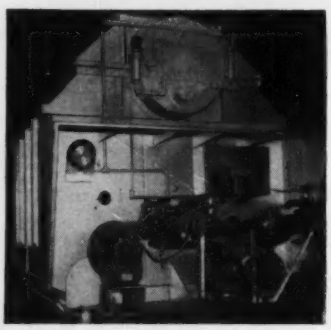
Developed by Navy, available to industry.

A new stationary boiler designed to reduce cost of the Navy's coal-fired steam generating equipment points to future savings for industrial users also. Under Navy direction representatives of most of the country's leading boiler manufacturers contributed to the design of the prototype unit to be installed shortly at a land base.

New standardized design covers steam capacities from 10,000 to 25,000 lb. per hr. Design permits easy conversion from solid to liquid or gaseous fuels.

Completely assembled boiler is designed to release not over 35,000 Btu. per cu. ft. of furnace volume to give best coal firing results. Chrome alloy steel baffles are used rather than refractory or castable baffles. Design also provides for fuel reinjection and over-fire air systems on both side walls and through the bridge walls.

Since the Navy's requirements are essentially those of private industry, it is stated that similar economies can be expected for all other prospective users.—**Superior Combustion Industries, Inc., Times Tower, Times Sq., New York 36, N. Y.** 252D



Packaged Vaporizer

For controlled temperature with Dowtherm.

Using Dowtherm A or E, *p*-cymene or anisole, Type MH packaged vaporizer produces high temperatures at low pressure. Control is simple, sensitive and uniform.

Vaporizer has compact three-drum design, is completely shop assembled. Operating on oil, gas, waste heat or special fuels, MH units run a slight positive pressure in the furnace. There is no need for an induced draft fan and stack height is reduced materially.

Type MH vaporizers are built to meet requirements from 3.7 to 15 million Btu. per hr.—**Union Iron Works, Erie, Pa.** 252E

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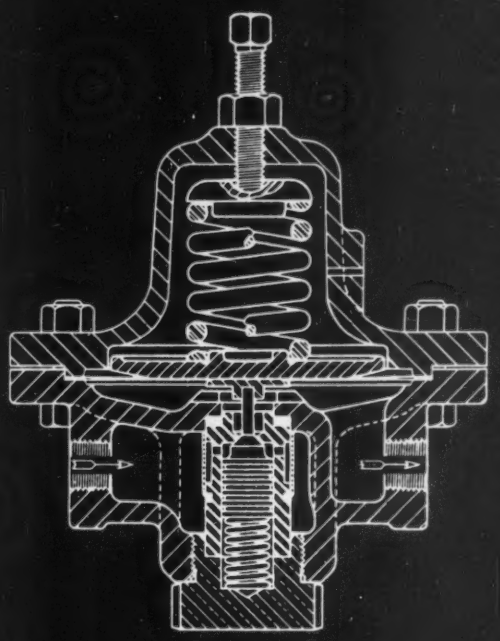
REDESIGNED—IMPROVED

THE CASH STANDARD TYPE D

Pressure Reducing and Regulating Valve

NOW . . . half the number of bolts saves maintenance time and . . . gasket seal at diaphragm flange provides easier pressure range conversion.

BUT . . . performance-wise it is still the same dependable valve that CASH STANDARD has offered for over 35 years to provide precise automatic control of most liquids, steam and gases.





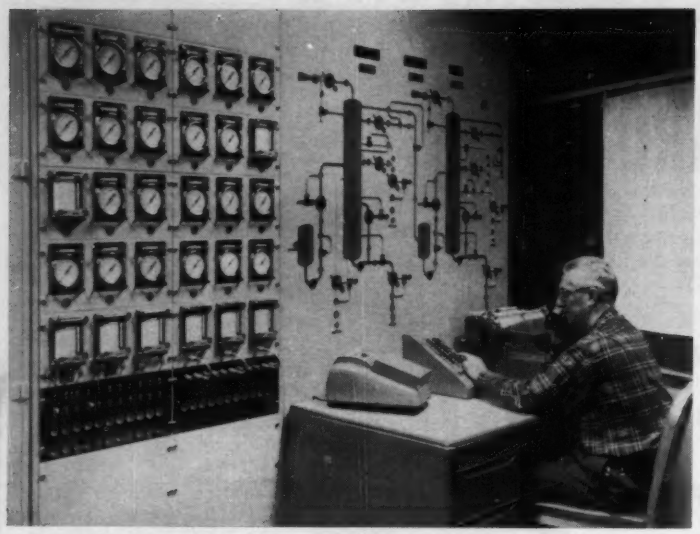
- Internal working unit still interchangeable with other models
- Interior easily accessible for quick cleaning or replacement
- Simple construction—minimum of parts
- Built-in strainer
- Available in iron, bronze, steel or stainless steel body, and bronze, stainless steel, nitralloy or monel trim
- Screwed ends, sizes ¼" to 2"

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PRESSURE, HYDRAULIC, TEMPERATURE, PROCESS AND COMBUSTION CONTROLS



Compact Process Data Center

Without leaving his desk this operator can instantly visualize, evaluate and act upon every processing irregularity, as it occurs. For this Trans-Scan-Log system is a compact intelligence center which combines coordination of all related process data with the most modern techniques of scanning and logging.

Indicators and recorder receivers are concentrated within minimum space. With these removed, graphic panel size is cut 75%.

▶ **Focal Point**—All related variables are directly in front of the operator. In the event of an off-normal condition he has all the data on which to base his decisions for corrective action. While all this goes on, process scanning continues at the rate of one point per second.

If the accounting or marketing departments require production data, as accumulated, it can be furnished on punched cards or tape.

Data on variables such as temperature, pressure, flow, level, load, density, pH, conductivity, viscosity, stress, speed, etc., are received from process by pneumatic or electric transmission. An adjacent panel with easily accessible relay racks electronically converts the process data to electrical impulse input to the digitizing and logging equipment.

▶ **Scans Continuously** — Points are scanned continuously at a one per sec. rate. A signal light glows in one of three colors to indicate the point being scanned and whether it is normal, below normal or above normal. Logging can be scheduled as required.

Off-normal conditions are indicated both audibly and visually. The visual signals remain until off-normal condition is corrected.

▶ **Flexibility Built In**—If process irregularity shows on the indicator, instrument can be unplugged and a recorder substituted within seconds. When the order of scanning must be changed it is done easily by replugging the relay racks. Change in basic process is easily reproduced on the graphic panel because there are no instrument cutouts.

By taking the drudgery out of previous manual logging operations, Trans-Scan-Log frees operators for more time at their prime function—maintaining maximum operating stability for the process.—**Taylor Instrument Cos., Rochester 1, N. Y.** 254A

Data Integrator

Combines computing and quality evaluation with data handling.

A new electronic data integrating system (EDIS) designed for Esso Standard Oil Co.'s Bayway refinery is believed to be the first system to incorporate computing and quality evaluation with conventional automatic data-handling operations.

The new system, priced in the $10,000-$50,000 range, will operate at Bayway on the production of a commercial solvent. It will automatically log temperature, pressure, flow, power consumption and product quality data. Running figures for flow and power will be totalled electronically at the end of the day. Average temperatures for the day from a number of critical points will also be computed electronically.

All data, translated into numbers, is fed automatically into electric typewriters. Flow and power measurements also are punched on tape for later use in cost accounting operations.

When not actually recording, system monitors a number of critical points. Off-normal deviations are spotted on an annunciator panel at the operator's desk. A slip in quality will sound an alarm.—**Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Ave., Philadelphia 44, Pa.** 254B

Weight Scanner

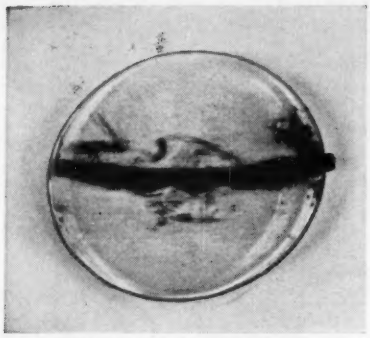
Transmits from scale to data handling machines.

A new digital-scanning electronic unit is claimed the first to transmit weights from scale to remotely located tabulating punch cards, adding machines or similar devices. It bridges the gap between indication of weight by the rotary movement of an indicator on a graduated scale and automatic recording of this weight in digital or numerical form at remote location.

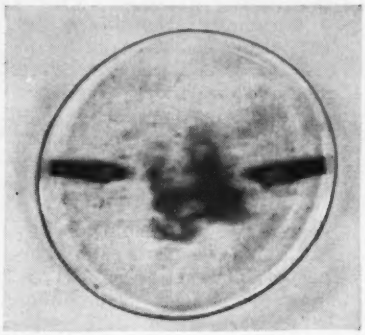
Values are converted with the normal accuracy of the original, without the electrical drift, non-

KEL-F® ELASTOMER
IS SHATTERING IDEAS ABOUT RUBBER

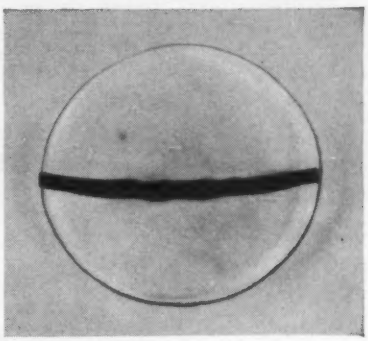
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CHEMICAL RESISTANCE...HEAT RESISTANCE



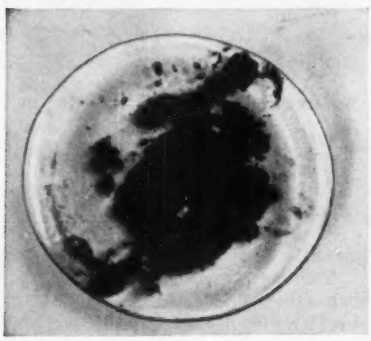
BUNA-N—10 min. immersion in RFNA



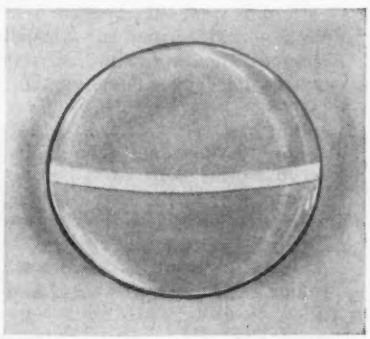
NATURAL RUBBER—10 min. immersion in RFNA



BUTYL—2 hr. immersion in RFNA



GRS—10 min. immersion in RFNA



KEL-F ELASTOMER—one week immersion in RFNA

IMMERSION IN RED FUMING NITRIC ACID for one week has no appreciable effect on the physical properties of KEL-F Elastomer. Extensibility and hardness remain virtually unchanged. Other available rubbers disintegrate within a matter of minutes.

When severe operating conditions demand a chemical rubber that *must* stand up under high temperatures and corrosive atmospheres—KEL-F Elastomer is the answer.

Developed by Kellogg, KEL-F fluorocarbon rubber combines superior elastomeric properties with excellent chemical resistance and thermal stability. Other outstanding advantages include: high chemical resistance to solvents, fuels and lubricants . . . low moisture absorption . . . non-flammability . . . excellent resistance to weathering and microorganisms.

This *unique* combination of properties makes KEL-F Elastomer useful in applications such as heat-and-chemical-resistant hose, tubing, diaphragms, gaskets, seals, tank linings, corrosion-resistant clothing, paints, flame-resistant coatings, and electrical insulation.

If your work requires an elastomer with outstanding resistance to heat and corrosion, look into KEL-F Elastomer. Our technical staff is prepared to assist designers, engineers, and production men in adapting KEL-F Elastomer to their individual needs. Kellogg supplies KEL-F Elastomer in the gum form only. Names of qualified fabricators of specific end uses of KEL-F Elastomer are available on request.

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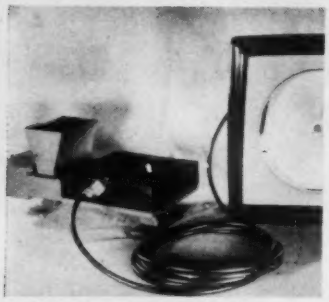
Firm_____ Position_____

Address_____

City_____ Zone_____ State_____

linearity or friction errors that were barriers to earlier efforts.

Basic element of the scanner is a motor-driven light source that scans lines exposed on a special chart. Output is a series of electrical pulses that pass through an electronic counter and translator to the remote recording or indicating device.—**Toledo Scale Co., Toledo, Ohio. 254C**



Moisture Meter

First automatic unit to measure, indicate, record and control.

Simple, new two-unit instrument continuously controls moisture content of free-flowing solids. Control of moisture variance is very accurate, increasing as the range of particle sizes narrows. Over-all efficiency of drying, cooling and tempering processes is increased appreciably.

The Rogers moisture controller consists of a forced feed test cell and recorder-controller. A small portion of the main stream is sent through the cell at a 100-200 lb. per hr. rate. In the cell, the stream is forced between electrode plates which measure the dielectric effect by capacitive reactance. Moisture is recorded and controlled with a capacitance bridge.—**The Quaker Oats Co., Mechanical & Electrical Div., 205 Water St., Akron 8, Ohio. 256A**

Control System

Is reliable, flexible and rugged.

The ElectroSyn system utilizes electro-magnetic elements to indicate, measure, record or control any number of process variables. It can be applied on pressure, differential pressure, flow, liquid level and temperature.

Basic ElectroSyn system has three components: a signal transmitter, a servo amplifier (magnetic) and a null balance indicator.

Transmitter contains a high resolution, electro-magnetic rotary transducer that converts measured variable to an a.c. signal that is proportional to the magnitude of the variable. Included in the null balance indicator are a second or slave ElectroSyn whose rotor is geared to a servo motor.

The two ElectroSyns are connected in a series and to the input of the magnetic amplifier. When positions of both rotors coincide the outputs cancel and no signal is applied to the magnetic amplifier input. When a change in the measured variable changes the alignment of the transmitter, the misalignment between the two rotors sends a signal to the amplifier. Output from the amplifier causes the servo motor to drive the slave ElectroSyn until it coincides with the transmitter. The indicating pointer is connected directly to the drive gears and indicates the magnitude of the quantity being measured.—**Norwood Controls, Unit of Detroit Controls Corp., 934 Washington St., Norwood, Mass. 256B**

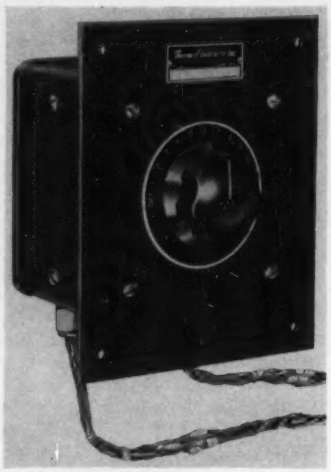
Photoelectric Analyzer

Automatically analyzes liquids, vapors or gases.

The new Model III photoelectric analyzer automatically analyzes liquids, vapors and gases to control chemical processes.

Instrument makes accurate record automatically for many days. By a self-monitoring feature it checks and resets itself to compensate for any smudge accumulation on cell windows or other similar sources of error.

Outstanding service on liquids is matched by ability to record down to a few parts per billion of gas or vapor in air. Concentration of effluent gas can be continuously recorded. Warning can be given automatically when noxious vapor is present in the air or when a system is leaking.—**Manufacturers Engineering & Equipment Corp., Hatboro, Pa. 256C**



Selector Switch

Rotary type for pyrometers.

A new series of rotary selector switches for either thermocouple or resistance bulb circuits has been announced.

Switches are double pole "shorting-type" (make-before-break). Easily accessible contacts and wipers are made of the same silver alloy so there is less possibility of false voltages from thermoelectric action.

Three models cover a range of 6, 12 and 24 circuits.—**Thermo Electric Co., Inc., Rochelle Park P. O., Saddle Brook, N. J. 256D**

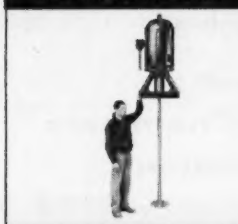
Magnetic limit switch operated by movement of magnet located up to 3 in. away from switch. Eliminates need for direct contact between moving part and switch.—**Femco, Inc., Irwin, Pa. 256E**

Instrument enclosure for meters and gages on hazardous locations permits instrument to be read without opening enclosure. It's equipped with threaded cover and a heavy round glass window.—**Pyle-National Co., 1334 North Kostner, Chicago, Ill. 256F**

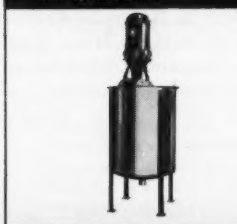
MANY MODELS TO CHOOSE FROM
—special engineering adaptations if necessary



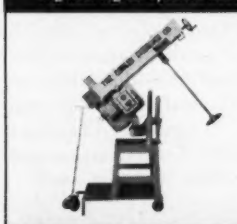
10-20V with hydraulic lift. For big-volume production. Height, max. lift, 122". 10-30 HP.



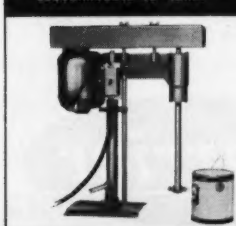
10-20D, for installation on your own tanks. For adaptation up to 40 HP.



20D—Tank Type. Standard models for capacities of 100, 250 and 500 gallons. Special engineering for specific needs.



7-VTV—Mobile Tip-Up Type. For 5 to 80 gallon batches. Width 41/2". Max. tilt will accommodate 46" tank.



1-VT Laboratory Tip-Up Type. For testing, pilot plants and small batches. Results identical to production-size models. Max. rise, 44".

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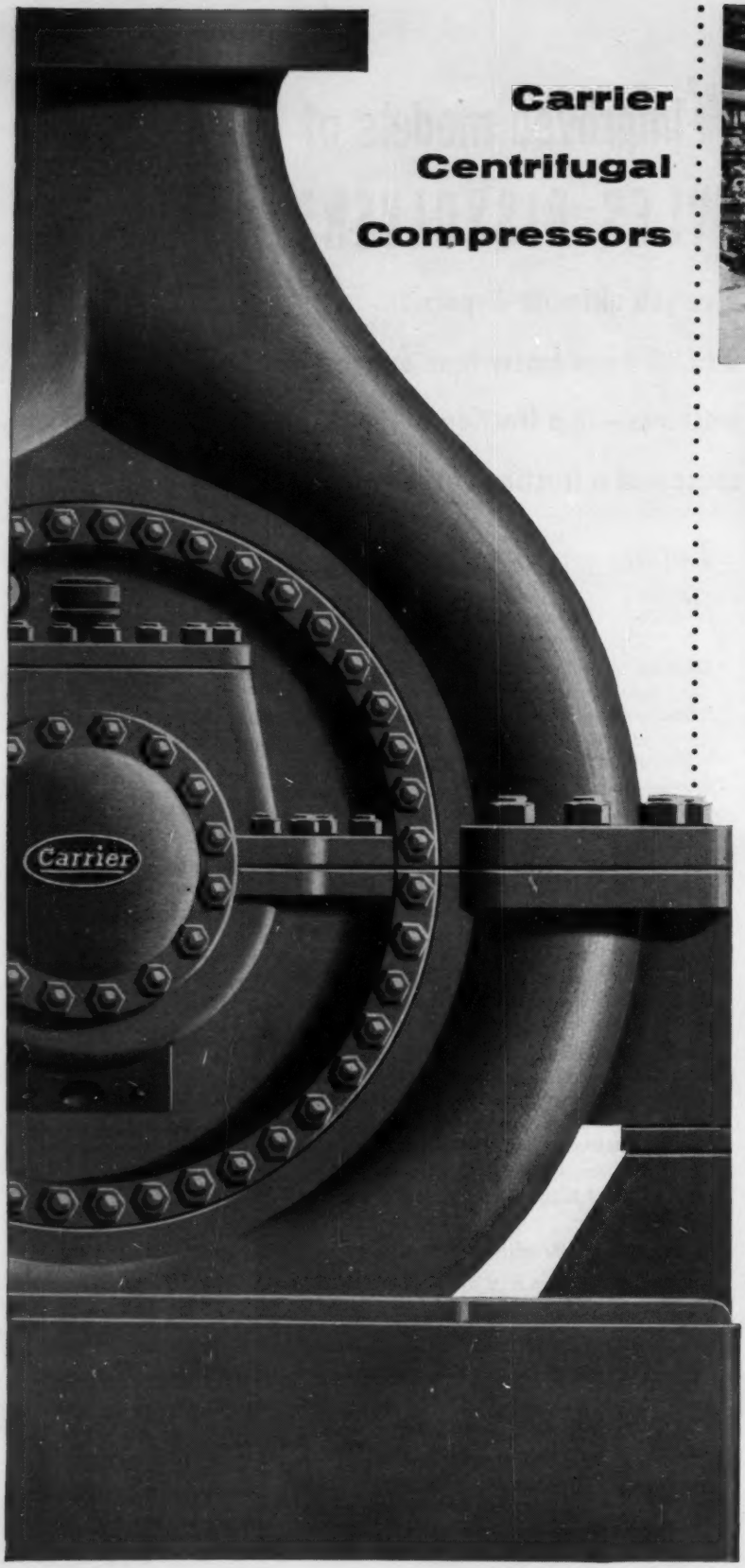
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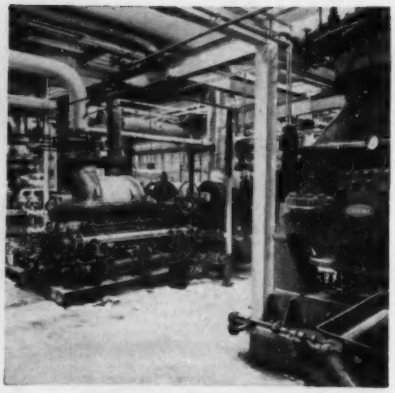
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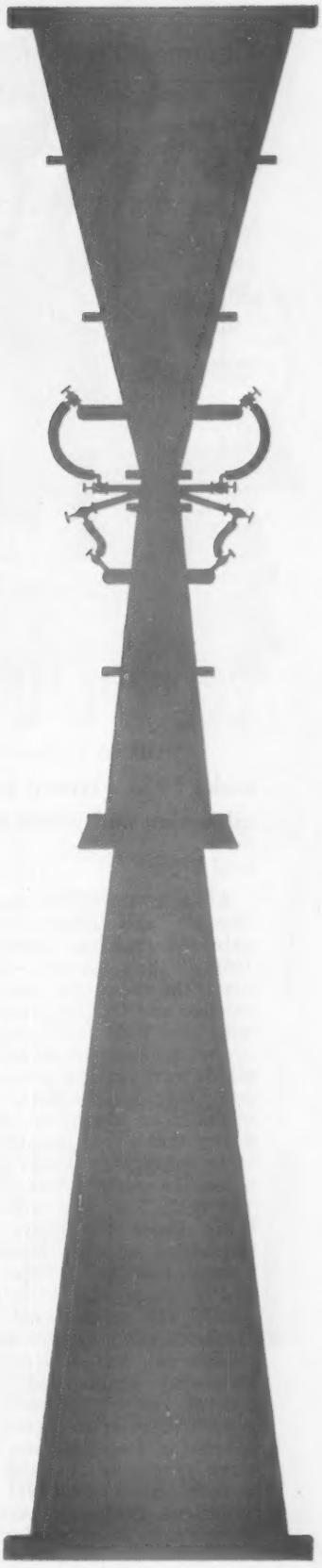
really tough
gas-cleaning problems

Sub-micron fumes are the **really tough** gas cleaning problems. These fumes cannot be economically or effectively controlled by conventional cleaning devices.

However, the Chemico P-A Venturi Scrubber is proving its success in solving these **really tough** problems in more than 150 commercial installations and in more than 70 pilot investigations.

The table lists some of these commercial installations. All of these **really tough** problems and many more are being solved with complete satisfaction to users of P-A Venturi Scrubbers.

PROCESS	DUST OR FUME	INSTALLED CAPACITY CFM
Incinerator—Flue Fed	Fly Ash	32,000
Incinerator—Sodium Disposal	Na_2O	9,000
Incinerator—Industrial	Radioactive Dust	6,000
Dry Ice & CO_2 Plants	Amine Recovery	72,400
CO_2 Gas for Process	Fly Ash	500
Boiler Flue Gas	Fly Ash & SO_2	4,300
Enamel Frit Furnace	Dust & HF	11,900
H_2SO_4 Concentrator	H_2SO_4	49,800
Copperas Roasting	H_2SO_4	34,250
Cobalt Ore Roasting	H_2SO_4	65,000
Chemico Wet Type Acid Plant	H_2SO_4	41,000
Chloro-Sulfonic Plant	H_2SO_4	600
Phosphoric Acid Plant	H_3PO_4	91,900
Phosphoric Acid Concentrator	H_3PO_4	194,000
Phosphor Copper Furnace	H_3PO_4	15,000
Smelting—Non-Ferrous		
Blast Furnace	Lead & Organic	12,000
Reverb. Furnace	Lead Compounds	23,500
Comb. Blast & Reverb.	Lead Compounds	7,000
Brass Furnace	Zinc Oxide	7,500
Ajax Furnace	Beryllium Fumes	4,000
Steel Plant		
Oxygen Steel Process	Iron Oxide	140,000
Blast Furnace	Coke & Iron Oxides	788,000
Zinc Sintering	Zinc Oxide	75,000
Wood Distillation	Tar Products	3,500
Na_2SiF_6 Dryer	SiF_4 & Dusts	700
Iron Chloride Concentrator	$FeCl_2$ & HCL Mist	40,000
Unknown	Carbon Black	1,700
Lime Kiln	Lime & Na_2O	18,000
Detergent Spray Dryer	Chemical Fume	250,000
Furfural Residue Burner	Fly Ash	36,000
Nodulizing Kiln	Manganese & Lead	25,000
Aluminum Pot Lines	Tar Fog, Fluorides	40,000
Carbide Furnace	Metal Oxides	1,000
Asphalt Plant	Rock Dust	80,000



Write to our P-A Sales Department for Bulletin M-102 describing the simple operating principle of the P-A Venturi Scrubber, and Bulletin M-103 explaining its metallurgical fume applications in the steel industry.

CHEMICAL CONSTRUCTION CORPORATION

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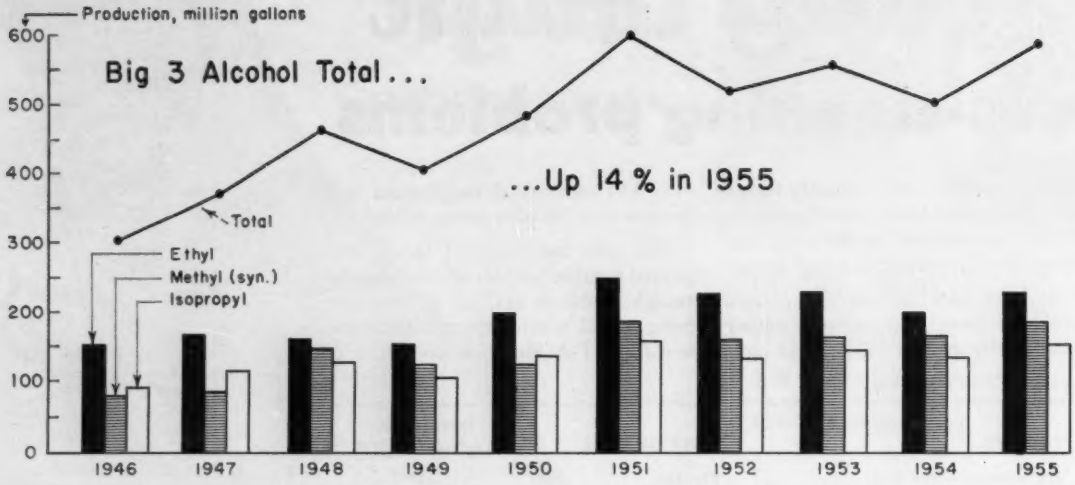
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CC 307



Solvents Hustled Through a Sellout

Off to a slow start, solvent sales finished fast to make 1955 a record year. Some of the products went on allocation and prices rose to start the new year.

After a slow first quarter, alcohols and other solvents gained momentum rapidly in 1955 as their markets—particularly the major ones like paint, varnish and textiles—expanded with the high level of prosperity. By midyear all solvents plants were running at capacity and certain products were virtually on allocation. An industry that a year ago appeared to be overproduced and facing a loss in markets was on the way to its best year in history.

▶ **Big Boost for Ethyl**—1955 production of ethyl alcohol is estimated at 235 million gal., 15.4% above the 1954 tally. About 178 million gal. was synthetic ethyl alcohol and 57 million gal. was derived from molasses, grain and other sources.

All inventories were exhausted by December and three large producers (Carbide and Carbon, Shell Chemical and Tennessee Eastman) were unable to keep up with sales. For although the opening inventory was 27 million gal., closing stocks were at the lowest level in many years.

Early in the year the price structure was a little unsettled. Demand was listless as France's stockpile of alcohol still hung over the U. S. market. But with the pickup in consuming industries, demand showed a normal, satisfactory increase.

In fact, one large synthetic ethanol producer was so short of alcohol by the end of the year that it purchased the entire inventory of French alcohol to be taken out over the next 18 months.

▶ **Call for Butadiene**—Ethyl demand was augmented by a call from the synthetic rubber plants for more butadiene. When the rubber plants were sold during the first half of 1955, inventories of synthetic rubber were at an all-time low. As consumption increased production promptly responded to reach 975,000 tons for the year.

Since plants turning out petroleum-derived butadiene couldn't sustain this rate the rubber plants looked to butadiene based on ethyl alcohol to meet their needs. Publicker's Louisville butadiene plant, which operates on ethyl alcohol, was reopened and is expected to operate well into 1957. Publicker is thought to have purchased a large quantity of invert molasses in order to operate the alcohol plant at full capacity.

▶ **Price Up 2¢**—Strong undercurrents in demand for ethyl alcohol—plus freight and wage increases—apparently justified, in the eyes of some producers, a price rise. At year's end, ethyl alcohol was up 2¢/gal.

While synthetic ethyl alcohol plants had operating difficulties in 1954, apparently all plants were operating at reasonably satisfactory levels in 1955. However, certain of the synthetic producers were short of ethylene as demand for that commodity in styrene, polyethylene and ethylene glycol manufacture showed a substantial increase.

▶ **Methanol Tight, Too**—The synthetic methanol market also kept pace with the over-all ex-



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panding economy. Production during 1955 is estimated at 195 million gal., 15.4% above 1954.

Inactive demand during the first quarter led some producers to make substantial export commitments. But increased domestic demand for formaldehyde and pentaerythritol, as well as for antifreeze, made for a very tight methanol supply by the end of the year. Most of the special prices, which held in 1954, disappeared.

Sales of wood alcohol were good. As usual, most was used as a denaturant.

▶ **Isopropyl, Acetone Gain**—Isopropyl alcohol production for 1955 is estimated at 160 million gal., 11.6% higher than in 1954, and reflects the same pattern shown in ethanol and methanol.

Demand for acetone, the largest consumer of isopropyl alcohol, was very slack for the first quarter. When two producers of acetone from cumene offered the solvent at extremely low prices, the price structure was fairly well demoralized.

However, with the pickup in the textile business and other markets for propylene, the acetone market firmed considerably. Three of the largest acetone producers closed out the year by having to purchase the solvent as demand exceeded supply.

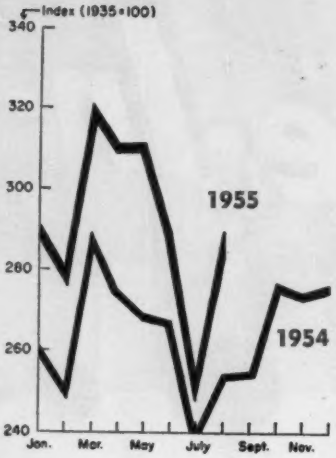
During the year Shell Chemical announced a new process for making glycerine which will use up fairly large amounts of isopropanol, although acetone will be obtained as a byproduct.

▶ **Other Ketones Strong**—The market for methyl ethyl ketone was very good. By the end of the year MEK was virtually on allocation and its price upped ½¢/lb.

Short supply was aggravated further as one of the large producers, Enjay, had operating difficulties late in the year. And MEK demand was good enough for Shell to announce expanded facilities which will come on stream early in 1957.

With demand for vinyls and nitrocellulose lacquers increasing, makers of methyl isobutyl ketone had trouble keeping pace. The strong market had much to do with the ½¢/lb. price rise scheduled for 1956.

Chemical Consumption



Consumption by Industries

	Oct. (Final)	Nov. (Est.)
Fertilizer	71.7	72.2
Pulp & paper	37.9	36.4
Petroleum refining	30.1	29.9
Iron & steel	19.3	18.8
Rayon	30.8	31.1
Glass	27.2	23.9
Paint & varnish	30.1	28.5
Textiles	10.6	11.1
Coal products	12.3	12.0
Leather	4.2	4.1
Explosives	10.1	9.6
Rubber	7.7	7.6
Plastics	26.4	25.9
Total	318	311

▶ **Esters Lose a Little**—The markets for the esters of ethyl, isobutyl and isopropyl alcohol were good but their growth factor has been checked.

Even though the protective coating business was excellent butyl esters continued to lose a little ground to MIBK; ethyl and isopropyl acetates still lose ground to MEK.

Because of the *sec*-butyl alcohol shortage during the year, Enjay, the major producer of *sec*-butyl acetate, was unable to meet demand and lost position in the market even though its product is well-priced.

▶ **Higher Alcohols Vary**—The solvent market's one weakness lies in the excess production during most of the year by the two producers of isobutyl alcohol, Eastman and Celanese, which made them inclined to dispose of IBA at distressed prices when their tanks were full.

But the demand for normal butyl alcohol, *sec*-butyl alcohol, and their acetates was good enough to warrant a ½¢/lb. price hike at the end of the year.

And the market for amyl alcohol likewise was strong throughout the year. Sharples, the big producer, found its position threatened as Eastman and Carbide and Carbon entered the higher alcohol domain via the Oxo process. For although Oxo productions was insignificant in 1955, it looks like production costs will be significantly below those of Sharples. Within a year, look for a shift to lower-priced Oxo-plant amyl alcohols.

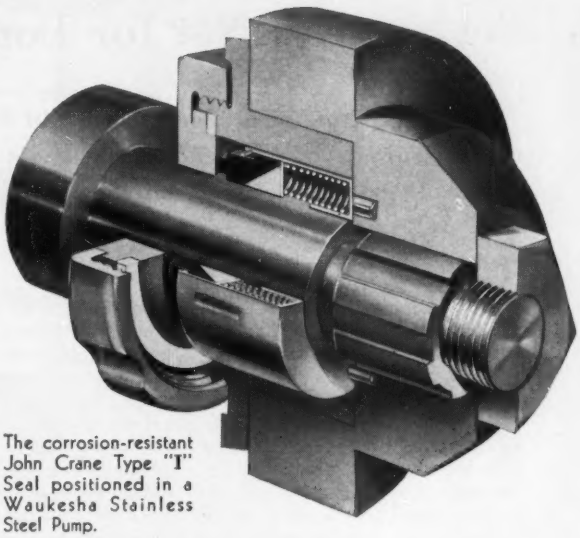
In fact, most C_4, C_8 and C_9 alcohols may be made more cheaply by Oxo reactions, a development which will help offset increasing distribution costs for these solvents.

▶ **A Look at 1956**—Encouraging as all this might be, it's still doubtful whether any new uses for alcohols and solvent products have been developed. Another complication: products in the plastics field, like polyethylene, vinyl polymers and various emulsions, will be chewing up more and more of the raw materials—such as ethylene, propylene and butylene—that would normally go into the production of alcohols and solvents. Producers of these solvent raw materials may not feel the same urgency to sell their products as they have in the past few years.

The price-shading that was such a disturbing factor in 1955 may carry over into 1956, despite the announced price increases. (If the market shifts even nominally, prices may well tend to soften.) When Stanolind puts its large synthetic plant in Texas on stream this spring after extensive rehabilitation, its efforts to find a place in the solvents market will have a disturbing effect on 1956 prices.

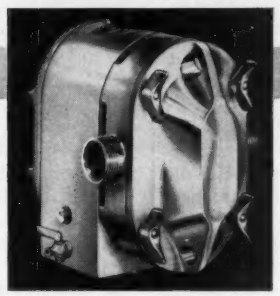
Nevertheless, we look to 1956 to be a good year for solvents. Demand will continue to increase, at least during the first half, and prices will remain firm.

The P. D.* Pump for the chemical and petroleum industries



The corrosion-resistant John Crane Type "1" Seal positioned in a Waukesha Stainless Steel Pump.

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New Records Set . . . But Not for Long

All Oil . . .
(million bbl.)

	Demand	Production
'55	3,053	2,732
'54	2,829	2,565
'53	2,775	2,596
'52	2,664	2,514
'51	2,570	2,453

Motor Fuel . . .
(million bbl.)

	Demand	Production
'55	1,319	1,343
'54	1,238	1,269
'53	1,206	1,266
'52	1,157	1,193
'51	1,090	1,140

Fuel Oil . . .
(million bbl.)

	Demand	Production
'55	1,128	1,020
'54	1,048	959
'53	1,049	978
'52	1,035	974
'51	1,012	945

Jet Fuel . . .
(million bbl.)

	Demand	Production
'55	59	58
'54	46	50
'53	35	40
'52	20	25
'51	0	0

Lubricants . . .
(million bbl.)

	Demand	Production
'55	56	55
'54	38	53
'53	40	52
'52	38	55
'51	42	62

Refinery Capacity . . .
(thousand bbl./day)

'55	8,535
'54	8,421
'53	8,007
'52	7,639
'51	7,333

Riding the biggest groundswell in five years, petroleum supply and demand reached all-time highs in 1955. Outlook for 1956: more broken records.

Raymond F. Fremed, Assistant Editor

It was hard to find a really unhappy oilman in the U. S. as 1955 drew to a close. Total consumer demand for petroleum products in 1955 swept past the 3-billion-barrel mark (the 13th consecutive year that demand has increased). And with operations crowding 90% of capacity, the American refining industry was running hard just to keep up.

Not that there was any dearth of material for refiners to work up, what with 2.7 billion bbl. of crude oil being run to stills in 1955. It was just that demand was pushing refining facilities for all they were worth.

From the 1954 level of 7.7 million bpd., domestic demand rose to 8.36 million bpd.—up 7.9%. Exports of finished products were up to 373,000 bpd. from 1954's figure of 356,000 bpd. So total demand in 1955 was about 8.7 million bpd., 7.4% above the 8.1 million bpd. mark of 1954.

What were the factors that contributed to this prosperous year for the oil industry?

• American automobile manufacturers were able to put some 8,000,000 new passenger cars and 1,250,000 new trucks onto our nation's already overcrowded highways.

• We had some exceptionally cold weather during the 1954-55 heating season. And the 1955-56 season picked right up where the other left off. Coupled with this: oil heater installations in '55 were between 800,000 and 900,000 (probably at the third highest level ever).

• Military budgets are still at high levels. Jet fuel demand is way up.

• Civilian air travel reached an unprecedented volume and dieselization of our railroads is nearly complete.

• Petroleum products and natural gas continued to gain preference as fuels at the expense of coal.

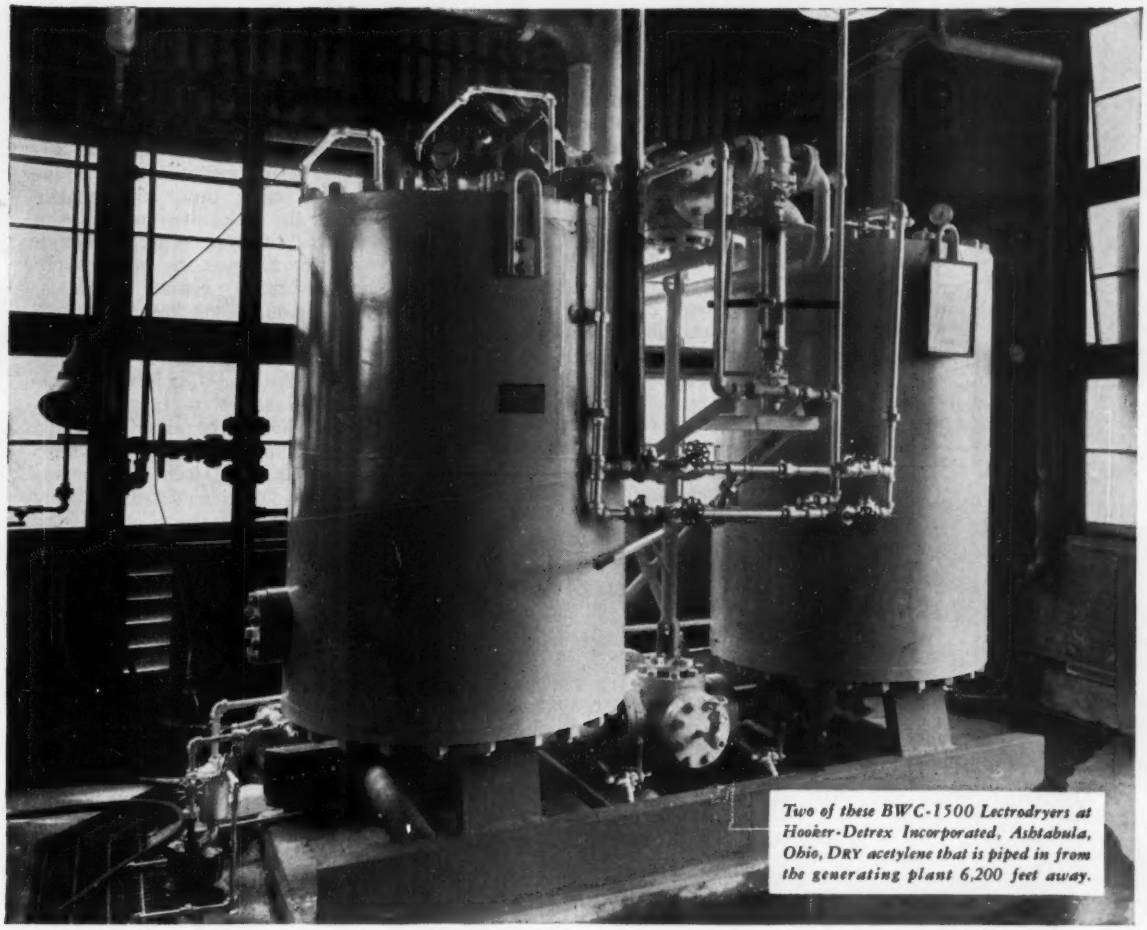
▶ **Prices High, Firm**—In general, prices for crude petroleum and refined products either held firm or went up in 1955. It was a strong market year.

Lubricating oil refiners were the biggest gainers. In Pennsylvania at year's end, lube oil refiners were getting 22¢/gal. for 25 pour-test bright stock, against 14.5¢/gal. at the end of 1954. Pennsylvania cylinder stocks rose 5.5¢/gal. Bright stock was up 4¢/gal. at the Gulf, 2¢/gal. in the Mid-Continent.

Gasoline, the biggest moneymaker for refiners, pretty much held its own. An 11¢/gal. price for 90-octane regular grade held steady at the Gulf Coast in December. Residual fuels chalked up substantial gains—40¢/bbl. in the Mid-Continent, 25¢/bbl. at the Gulf, 30¢/bbl. along the East Coast and about 15¢/bbl. on the West Coast.

▶ **Crude Price Steady**—While the prices of most refined products were inching upward, the cost to the refiner for crude petroleum held essentially unchanged. According to the U. S. Bureau of Mines report on mineral operations in 1955, crude petroleum at the well averaged $2.77/bbl.—about the same as in 1954.

▶ **Some Discontent** — This all sounds good. But there are rumblings beneath the surface in this land of plenty. For while it's true that petroleum companies were expanding production capacity, oilwell completions, refining facilities, transportation lines and marketing outlets



Two of these BWC-1500 Lectrodryers at Hooker-Detrex Incorporated, Ashtabula, Ohio, DRY acetylene that is piped in from the generating plant 6,200 feet away.

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Whether you're needing to DRY air, gases or organic liquids, there's a standard Lectrodryer to handle the job. For recommendations on this equipment, and for the book *Because Moisture Isn't Pink*, write Pittsburgh Lectrodryer Corp., 303 32nd Street, Pittsburgh 30, Pennsylvania.

* In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

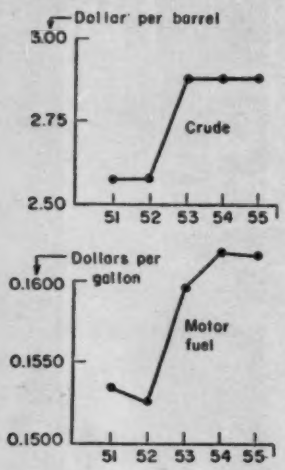
LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

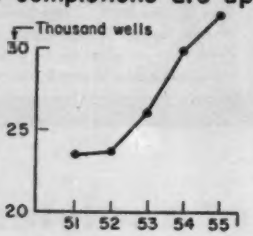
* REGISTERED TRADEMARK U.S. PAT. OFF.

Oil's Strength for '56

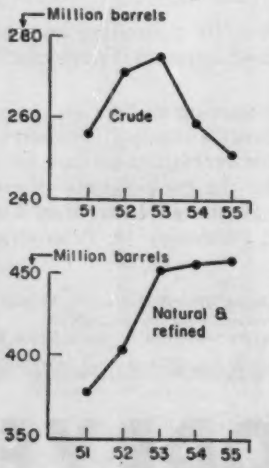
Prices are firm



Well completions are up



Inventory is steady



In 1955, one statistic took a nosedive. That was the number of natural gas well completions.

For the first time in recent years, gas well completions dropped—from 3,974 in 1954 to 3,600 in 1955. That's almost a 10% decrease.

There are those, API president Frank M. Porter for one, who blame this condition on the U. S. Supreme Court decision in the so-called Phillips case. As a result of this decision, natural gas producers who move their gas across state lines are subject to the controls and price schedules of the Federal Power Commission.

▶ **Fight in Congress**—Producers appear to be shunning the increasing demand for natural gas rather than put themselves in the hands of the FPC.

Of course the productions of natural gas, liquefied petroleum gas and refined petroleum products are economically interrelated. Should natural gas supplies fail to meet demand, the consumer is going to have to pay for the imbalance no matter which fuel he is committed to.

This has become a problem of national interest that is being fought in the Senate (the Harris-Fulbright bill) as you read this.

▶ **What About 1956?**—The petroleum industry looks to 1956 as another year of prosperity. All available forecasts predict still another increase in total demand for petroleum products.

Most conservative prediction is that of the Bureau of Mines. B. of M. estimates a 4% increase to over 9 billion bbl. average daily demand. Other forecasters have pegged the increase somewhere between 6 and 7%.

▶ **How to Share It?**—Who will get what share of this increasing market? Aye, there's the rub!

Importers claim they aren't being given a big enough slice. It's good for foreign relations and the future of U. S. resources, they say, to increase our purchases of foreign crude petroleum.

Those that don't import accuse the importers of being too greedy. They claim that importers brought more oil into the country in 1955 than they should have and ought to be cut back in '56.

▶ **Enough For All**—At the annual API meeting in San Francisco, more than one speaker told the delegates to stop the petty bickering. There's enough oil for all, and the oil industry faces much graver problems, they said.

Oil executives complained about one of these problems: the shortage of qualified scientific personnel to carry out the expansion programs that are now being planned. Some have even classified technical personnel as "petroleum's most basic shortage."

▶ **Planned Expansion**—To what extent will the petroleum industry expand in 1956?

According to a recent McGraw-Hill survey (see *Chem. Eng.*, Jan. 1956, p. 262), petroleum refiners have budgeted a capital outlay of $825 million in 1956. This is the largest amount that this sector of the oil industry has ever budgeted.

In 1955 refineries were operating close to 90% of installed capacity. Increased refining facilities will certainly be necessary if predicted increases in demand pan out in '56. Octane requirements are going up every year, should hit 97 for the premium grade called for by 1957 model cars. This means that new processes and new equipment—especially catalytic reformers—will be needed to keep refiners in the competitive picture.

What with mounting demand, high-gear production and firm prices, it was hard to find a really unhappy oilman at the end of 1955. It shouldn't be any easier at the close of 1956.

Government Eyes Mounting Mergers

More than 3,000 concerns have disappeared in the swelling merger tide since 1951. At the end of 1954, mergers were being made three times as fast as in 1949. And in 1955, 500 were consummated, more than in any year since 1930 and a third more than in 1954.

Such were the recent findings of a House judiciary subcom-

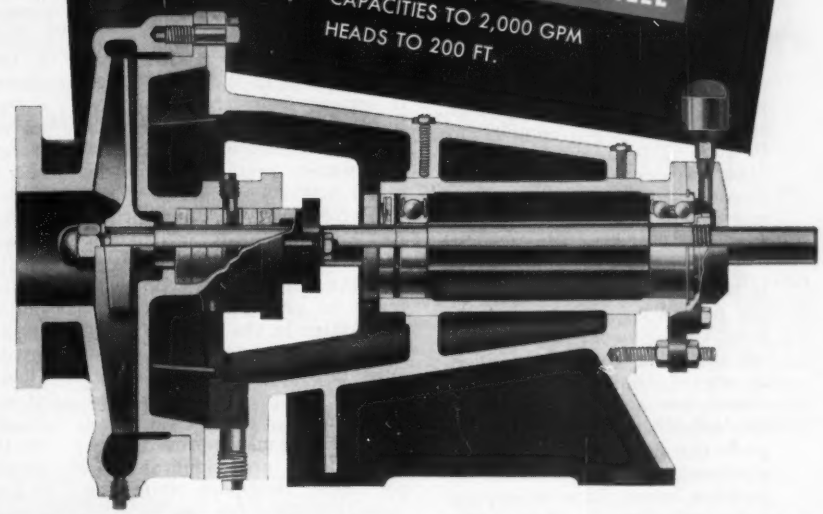
- Soap solution
- Calcium hypochlorite
- Water containing abrasive particles
- Carbon slurry
- Ferric hydroxide
- Soap solution containing sand and ground glass
- 25% grape juice concentrate
- 50% caustic soda
- Ferric sulphate
- Ammonium sulphate
- Demineralized water
- Trisodium phosphate
- Reactivated carbon
- 1% chlorine solution
- Sulphuric acid
- 10% chromic acid
- Humic acid
- Weak black liquor
- Waste sulphite liquor
- Bleach liquor
- Slurries
- Acid mine water
- Liquid latex
- Alkylaryl sulfonate
- Sodium hydroxide
- Calcium hydroxide
- Calcium bisulphite
- Calcium hypochlorite
- Demineralized water

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DE LAVAL STEAM TURBINE COMPANY

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DL-931

mittee. With the announcement of these statistics came the warning that "the growing number of corporate mergers is rapidly reducing competition in industry and contributes in large measure to the growing concentration of economic power."

Whether or not this is true, the chemical industry, with its share of mergers, will be in the general spotlight as federal agencies look harder for antitrust violations.

The government is not only concerned over the number of mergers. It is also concerned with their character—the tendency of big corporations to buy up small businesses rather than for small firms to consolidate in order to compete more effectively with larger concerns.

And even though many recent mergers are the conglomerate type—the acquiring and acquired company produce different products not in the same stream of production and distribution—the subcommittee is urging more vigorous enforcement of antimerger laws.

Industry can offer strong arguments in defense of the conglomerate merger. The product diversification that comes with merger brings with it greater economic power and security, to be sure. But this in turn provides greater stability, product development and improvement, and benefit to the economy as a whole.

The government's viewpoint is that what benefits the merging parties does not necessarily benefit the economy as a whole. An acquiring corporation, if it is one of the "giants" of industry, can use the resources of its established businesses to push the new product line regardless of immediate profits or, perhaps, losses. In so doing, say some government officials, the big company may use methods that seriously injure competition.

Despite the boom in mergers, scarcely a dozen have been contested in four years. This amazing contrast would seem to indicate both a high proportion of genuinely beneficial mergers and a lack of aggressiveness on the part of the government. What with the increased Congressional prodding for action, two things are likely this year. Most corporate mergers will receive more positive approval; but some may be on their way to the chopping block.

Producers Ship More Chemicals by Boat

Until 1945 the railroads were the method of choice for chemical transport. Since then movement via truck and boat has fast been increasing in favor—although railroads still carry the largest tonnage. Oliver Beutel, traffi manager of Dow Chemical's exas Division, thinks the strongest future trend will be to chemical shipment over the waves.

Beutel cites these factors behind the increasing popularity of marine transportation:

- The chemical industry—already paying high rail freight rates—found the going rough when rates were raised at the end of World War II, and so looked for other transportation means.
- Volume of chemical production grew to the point where it became definitely economical to move material by water and desirable to expand in areas having water routes leading to major markets.
- New marine equipment for handling chemicals was developed: the double-skinned barge and the barge with cylindrical tanks to prevent product contamination in the event of leakage; pressure barges and pressure tankers for propane and butane; and refrigerated barges for ammonia.
- Small tankers proved more and more uneconomical for petroleum transport, thus became available for the smaller chemical movements.

Petro-chemical makers took the lead in water transportation, says Beutel, because, unlike the rest of the chemical industry, petrochemical location-pattern doesn't conform closely with the national consumption-pattern. Large volumes of material must be moved all the way from the Southwest to the Midwest and East Coast. Water transport has proved to be the answer despite relatively high capital costs for equipment.

Among the modified oil tankers and cargo ships are Warren Petroleum's "Natalia Warren," a carrier with a specialized design for propane and other pressurized chemicals; Carbide & Carbon's "R. E. Wilson," carrying assorted cargoes of low density and high purity; and Dow Chemical's "Marine Chemist," for solvents, heavy chemicals and cargo.

The first ship designed from the keel up for the specific purpose of transporting liquid chemicals is Dow's 18,000-ton "Marine Dow-Chem," launched early in 1954.

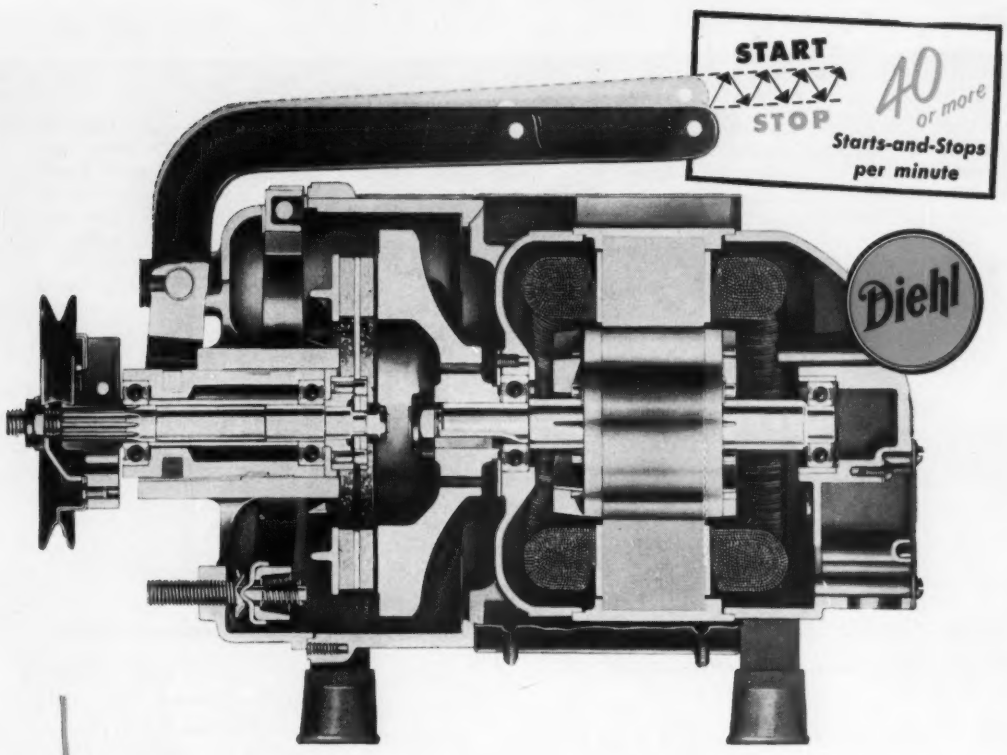
Fast Depreciation? —Plenty of Controversy

Whether to permit fast write-off of capital investment as a general rule or to use it only as an emergency measure—that's the question being argued in a good many places. Most of the controversy is prompted by the government's decision last year to temporarily suspend, in most cases, the granting of certificates of necessity. These permitted depreciation write-off for many defense-supporting projects in five years instead of the usual 20 or less.

The government acted on the grounds that with security capacity pretty much in place, accelerated amortization was costing too much revenue. To make the transition less abrupt, regular depreciation laws were liberalized, now permit the write-off of roughly two-thirds to three-fourths of plant equipment cost in the first half of estimated service life.

Some private authorities support this stand with some going so far as to opine that fast depreciation tends to aggravate recessions. Others feel any suspension of fast write-offs will be costly to both industry and government. Producers will have to be more cautious, will perhaps allow shortages to occur before expanding to meet them. And the lower rate of plant installation means less federal revenue, too.

Many of those who think the



New DIEHL Type "J" Power Transmitters

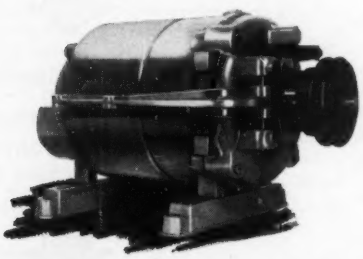
Unequalled for Repeated Start-Stop Machine Operation

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HIGH INERTIA FLYWHEEL • TOTALLY ENCLOSED MOTOR

Repeated, rapid start-stop machine operation, impractical with conventional motor drives, is now obtainable with Diehl Power Transmitters. Forty or more starts and stops per minute, hour after hour, are commonplace with these drives. Many manufacturers have made substantial increases in machine output by the shortening of acceleration and deceleration waiting periods.

In one compact unit, the Diehl Power Transmitter incorporates a totally-enclosed fan-cooled ball bearing motor; a high inertia, dynamically balanced flywheel; a positive short-throw, lever-actuated clutch brake assembly. The actuation may be controlled mechanically or electrically.

These Power Transmitters are now used extensively on machine tools, textile machinery, winding and spooling equipment, conveyors and many other types of machinery where repeated starting and stopping is required. In countless instances, the use of Diehl Power Transmitters has made it possible to simplify machines, reduce costs, improve operation, save space and eliminate over-motoring solely for acceleration. Many of *your* troublesome machine drive problems may be solved with Diehl Power Transmitters.



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OTHER INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

present setup is the most realistic compromise look on accelerated depreciation as a tested governmental device to help perk up business activity should it lag seriously.

No matter what the system for depreciation though, there's a definite insistence that price inflation be considered when determining depreciation allowances. Corporations should be able to figure the cost of equipment purchased in a prior period in terms of current dollars. For instance, 1955 dollars buy only about half as much plant as did 1940 dollars. Yet under present law an investor must treat one dollar as the equivalent of the other. Thus, the law assumes the owner is breaking even when actually he is recovering only 50% of the replacement cost.

GUIDED TOUR CONTINUED

PICTURED FLOWSHEET

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Chemical Technology of Fermentation . . . . . Apr.

Economics of Radiochemical Plants . . . . . Apr.

Liquid Proportioning . . . . . May

Problems in Handling Liquefied Gases . . . . . May

Handling of Compressible Fluids . . . . . June

Lithium Chemical Boom

Clever process engineering signalizes the remarkable upsurge in Li chemicals capacity. Here is the story behind Lithium Corp.'s new "acid" process plant at Bessemer City, N. C. (p. 294)

Stirring up a lot of interest, American Lithium Chemicals has just started up a new $6.6 million Li chemicals plant at San Antonio, Tex. Here are exclusive details on their clever "alkaline" process. (p. 208)

Find it hard to keep up?

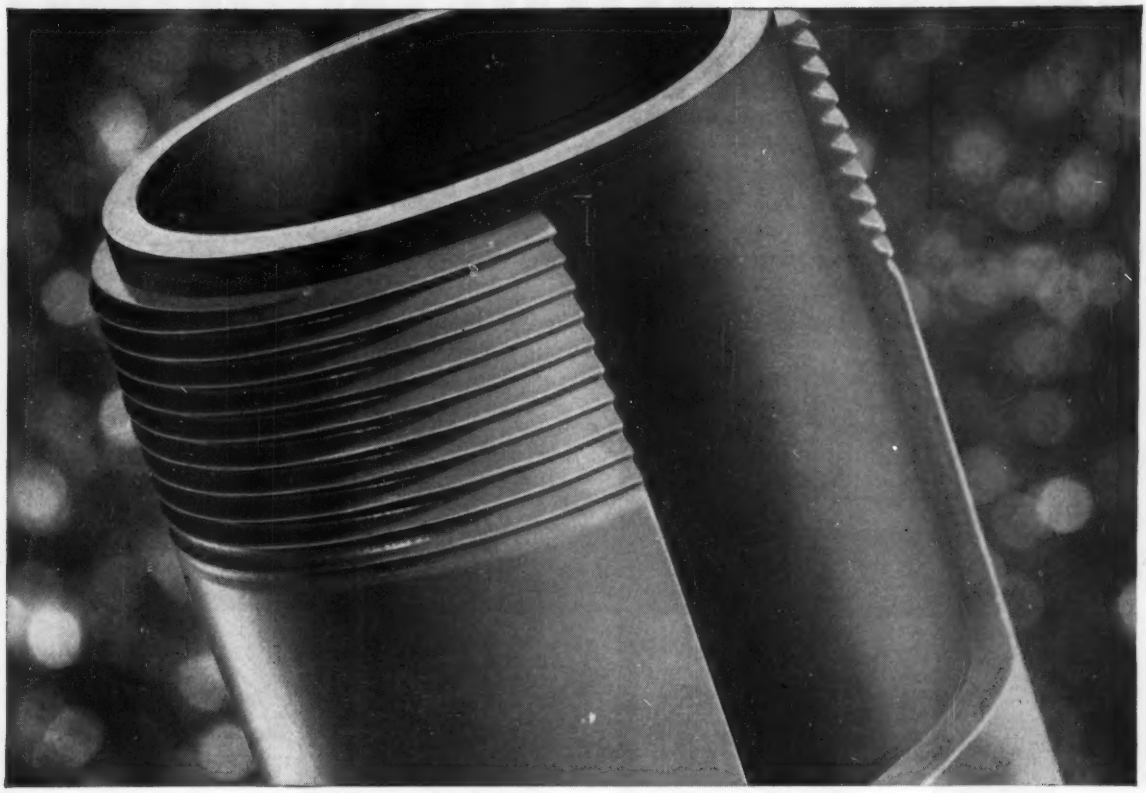
Maybe you should keep closer tabs on new reference books coming out. Technical Bookshelf is your monthly guide. (p. 311)

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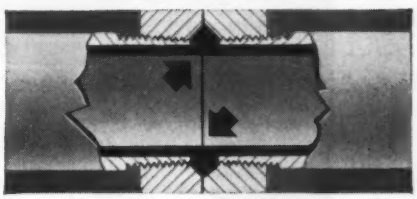
You can see why Saran Lined Pipe cuts corrosion costs

It's made of corrosion-resistant saran swaged into rigid non-bursting steel . . . liquid never touches metal in these installations

Here's your best way to convey acids, alkalies and other corrosive liquids—saran lined pipe, fittings and valves. This modern piping is corrosion resistant . . . forms snug, leakproof joints . . . is available for working pressures up to 150 psi. Fittings and valves are also available in steel for working pressures to 300 psi.

Installation costs are low with saran lined pipe, fittings and valves. Saran lined pipe can be cut and threaded in the field with available pipe-fitters' tools. Its rigidity means few supporting structures are needed.

Saran lined pipe has an outstanding record of trouble-free performance in the chemical, petroleum, waste, pulp and paper, metal finishing, and food processing industries. For further information send in the coupon at the right. THE DOW CHEMICAL COMPANY, Midland, Michigan.



Liquid never touches metal in saran lined pipe even at a flanged connection like this.

Saran Lined Pipe Company
2415 Burdette Avenue
Ferndale 20, Michigan
Dept. SP625A-1

Please send me information on saran lined pipe, valves and fittings.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

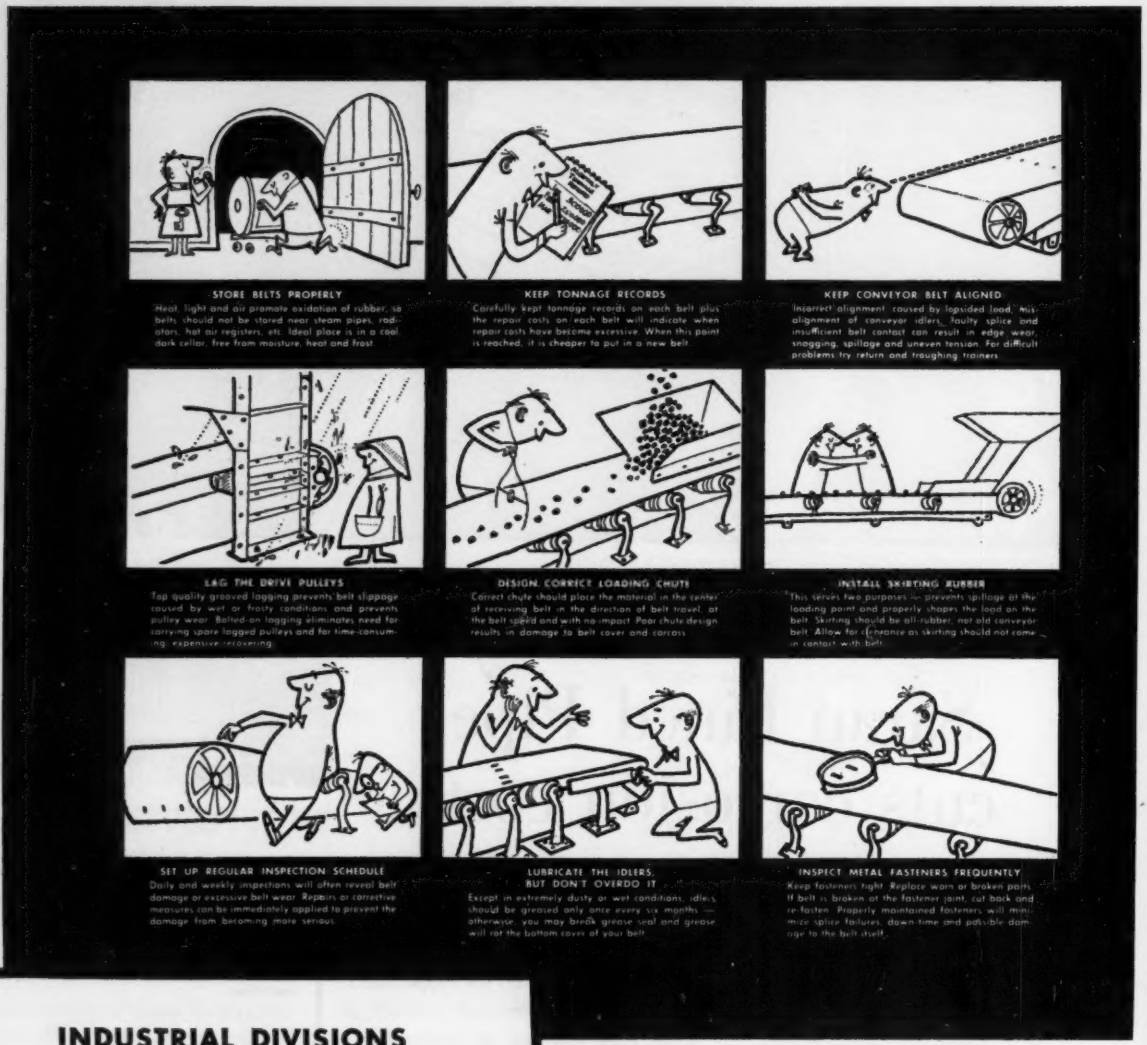
Saran Lined Pipe is Manufactured by The Dow Chemical Company, Midland, Michigan

you can depend on DOW PLASTICS

DOW

MORE CARRY IN YOUR

Free Wall Chart gives



STORE BELTS PROPERLY
Heat, light and air promote oxidation of rubber, so belts should not be stored near steam pipes, radiators, hot air registers, etc. Ideal place is in a cool, dark cellar, free from moisture, heat and frost.

KEEP TONNAGE RECORDS
Carefully kept tonnage records on each belt plus the repair costs on each belt will indicate when repair costs have become excessive. When this point is reached, it is cheaper to put in a new belt.

KEEP CONVEYOR BELT ALIGNED
Incorrect alignment, caused by lopsided load, misalignment of conveyor idlers, faulty splice and insufficient belt contact can result in edge wear, snagging, spillage and uneven tension. For difficult problems try return and troughing troiners.

LAG THE DRIVE PULLEYS
Top quality grooved lagging prevents belt slippage caused by wet or frosty conditions and prevents pulley wear. Bolted-on lagging eliminates need for carrying spare lagged pulleys and for time-consuming, expensive recovering.

DESIGN CORRECT LOADING CHUTE
Correct chute should place the material in the center of receiving belt in the direction of belt travel, at the belt speed and with no impact. Poor chute design results in damage to belt cover and carcass.

INSTALL SKIRTING RUBBER
This serves two purposes — prevents spillage at the loading point and properly shapes the load on the belt. Skirting should be all-rubber, not old conveyor belt. Allow for clearance as skirting should not come in contact with belt.

SET UP REGULAR INSPECTION SCHEDULE
Daily and weekly inspections will often reveal belt damage or excessive belt wear. Repairs or corrective measures can be immediately applied to prevent the damage from becoming more serious.

LUBRICATE THE IDLERS, BUT DON'T OVERDO IT
Except in extremely dusty or wet conditions, idlers should be greased only once every six months — otherwise, you may break grease seal and grease will rot the bottom cover of your belt.

INSPECT METAL FASTENERS FREQUENTLY
Keep fasteners tight. Replace worn or broken parts. If belt is broken at the fastener joint, cut back and re-fasten. Properly maintained fasteners will minimize splice failures, down-time and possible damage to the belt itself.

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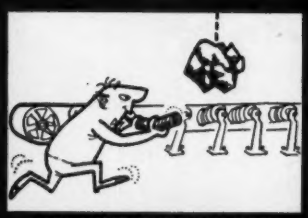
This wall chart, 23" x 33" in two colors, has many valuable tips that will enable you to increase the life of your conveyor belting. To obtain a copy, contact

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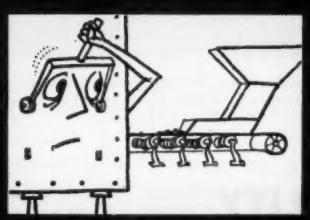
CONVEYOR BELTING

the answers



USE IMPACT IDLERS AT LOADING POINTS

Some of the shock of impact of rock points is absorbed by these idlers, resulting in less strain both on the carcass and covers of the belt.



MAKE USE OF AUTOMATIC SWITCHES

These switches will shut down the belting in case it breaks, in case of excess slipping on the drive pulley, or if the feeders or chutes "choke up."



REPAIR IMMEDIATELY CONVEYOR BELT DAMAGE

Unattended damage to the belt permits dirt and moisture to attack the fabric. Also, if the use of a damaged belt is continued, the impact and the sliding passage of injured areas over idlers and pulleys will enlarge the damage. The damaged spot should be cut out soon as noticed, and new rubber vulcanized into the hole.

your local HR Industrial Supply Distributor or write to our executive offices in Stamford, Connecticut.

Which is the best belt for you?

For Mining *(Metallic and Nonmetallic)*

Maltese Cross for especially severe service. Ajax for general heavy duty service, and Conservo for general light duty service. Exceptionally severe for special conditions may require use of specially designed Hewitt-Robins belts such as Shock Pad, CR-50 and CR-70, Raynile and Super-Raynile, Ajax Underground and Monarch Neoprene fire-resistant belting.

For Metal Processing

Maltese Cross for exceptionally severe service. Ajax for general heavy duty service, and Monarch Neoprene for oily service. Maltese Cross Fiberglas Hot Material, Maltese Cross Fabric type Hot Material and Hewitt Hot Service are especially designed for hot material handling.

For Public Utilities

Monarch Neoprene for oily service, Maltese Cross Hot Material and Hewitt Hot Service for hot material handling. Maltese Cross for especially severe service and Ajax for general heavy duty service.

For Food Processing

Canners and Packers and Hewlite for food handling, Monarch Neoprene for oily service, Ajax Rufftop, Conservo Rufftop and Conservo Transport for package handling. Monarch, Ajax and Conservo for grain and feed handling.

For Materials Handling

Conservo for portable conveyors. Ajax Rufftop, Conservo Rufftop, Conservo Transport and Hewlite for package conveyors.

For Chemical Processing

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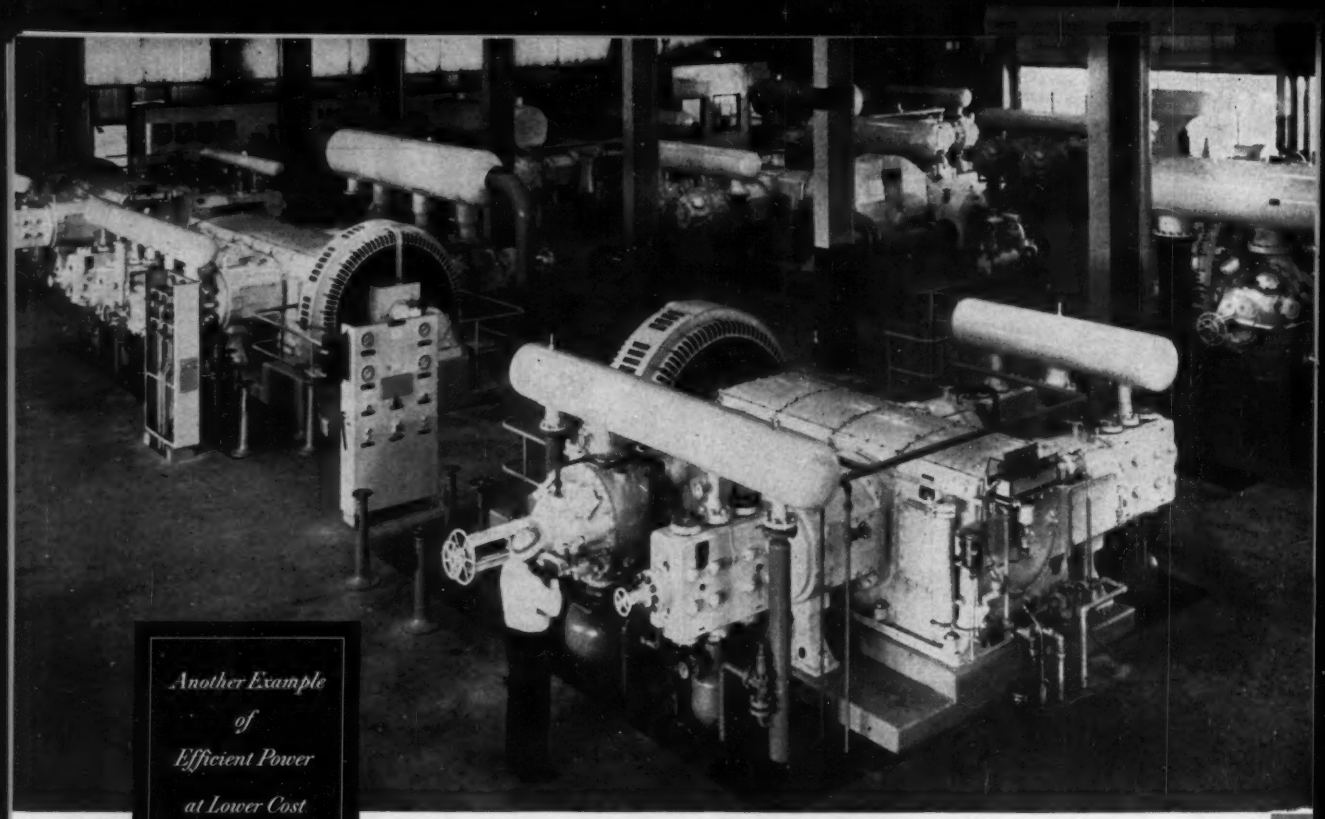
Maltese Cross for exceptionally severe service, Ajax for general heavy duty service, and Conservo for general light duty. Maltese Cross Fiberglas Hot Material, Maltese Cross fabric type Hot Material and Hewitt Hot Service are especially designed for hot material handling.

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Another Example of Efficient Power at Lower Cost

This over-all plant view shows several of the compact Cooper-Bessemer M-Line compressor units that deliver dependable performance in the Brea Chemicals, Inc. modern ammonia plant near Los Angeles.

HERE'S MULTIPLE-SERVICE FLEXIBILITY IN MODERN AMMONIA PRODUCTION

. . with Cooper-Bessemer JM Compressors

● Twelve Cooper-Bessemer JM compressors, totaling 17,500 horsepower, are doing an efficient, economical job of handling a wide range of compressor services in the Brea Chemicals, Inc. 13-million-dollar ammonia plant near Los Angeles.

JM-4's for air, ammonia, mixed gas, hydrogen and recycle service, and JM-6's handling nitrogen compression, offer important savings to this producer of 235 tons of ammonia daily.

Here, to list but a few, are reasons why Brea, like so many other modern chemical producers, benefits from Cooper-Bessemer's century of compressing experience: there's extreme flexibility to handle a wide range of pressures and different gases, advanced design and metallurgy afford unusual strength and rigidity, there's five-step unloading at constant speed, the crankshaft is a steel forging of exceptionally large diameter thus low unit bearing pressures, compressor cylinder jackets are designed to insure adequate, uniform cooling, and the JM's exceptional compactness does not sacrifice accessibility or ruggedness.

If you're interested in compressing, write or call for full details . . . learn about *all* the plus features of these modern units. The nearest Cooper-Bessemer office will gladly cooperate.

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FILTERAIDS

Paul W. Leppla, Technical Director

If your process includes a step where suspended solids – too fine to separate by settling – require removal from a liquid, filteraids may provide a solution to your problem. Chemical Engineers frequently fail to recognize potential filteraid applications, due probably to lack of familiarity with these materials.

Although there is no single typical application, a common characteristic of systems where filteraids are useful is the presence of suspended solids of natural origin, which cannot readily be characterized as to chemical composition or particle size. In fact, if you have a process liquor with less than 10% of particulates that settle out with difficulty, and whose exact nature and composition aren't known, the chances are very good that diatomite filteraids can be your answer.

In many cases the troublesome solids may be removed on a laboratory scale by filtration through fine cloth or filter paper, but the rate of filtration is reduced so rapidly by the deposition of an impervious layer of slimes, that a plant scale filtration operation operated on the same basis simply is impracticable.

The filtration engineer recognizes this situation as a "natural" for the use of a filteraid. Filteraids may be used with a variety of types of filtration equipment. The classical scheme provides for the addition of a small percentage of diatomite filteraid to the solution ahead of the filter. This is easily handled by the use of a simple proportioning feeder device.

Because of its unique porosity the diatomite "opens up" the layer of slimes as it is forming to such an extent that the flow is not choked off as the cycle progresses, and the volume of filtrate is increased a hundred-fold or even more.

The method of filteraid filtration offers the chemical engineer a process tool for clarification that is economical in first cost, operating cost, and maintenance. Cost varies depending upon the application, but filteraid addition frequently is in the neighborhood of 0.05%. Since filteraids cost 2-5 cents per pound, costs often fall into the range of 8-20 cents per thousand gallons filtered. In the clarification or polishing of relatively clear liquids, filteraid cost may fall below 1 cent per thousand gallons.



Dicalite Filteraids can give *Increased* clarity!

This is really an odd one. It started with a bottle of distilled water in a Dicalite laboratory, tight-stoppered in a sterile container. For certain reasons we had cause to question it. So we filtered it, using the finest grade of Dicalite filteraid—and removed microscopic solids which had survived distillation!

While this was a laboratory matter, it is of real importance to every man concerned with the clarification of process liquors, or with the separation of finely divided solids from liquids. If you require filtration so "sharp" that it will trap better than 95% of bacteria and other submicron-sized solids, there are Dicalite filteraids that do just that. Other Dicalite filteraids give faster flow-rates, yet still yield filtrates of sparkling clarity. No matter what your standard of clarity, there is a Dicalite filteraid which will meet it, or surpass it. We will be glad to advise with you on your particular process problems. Write us!

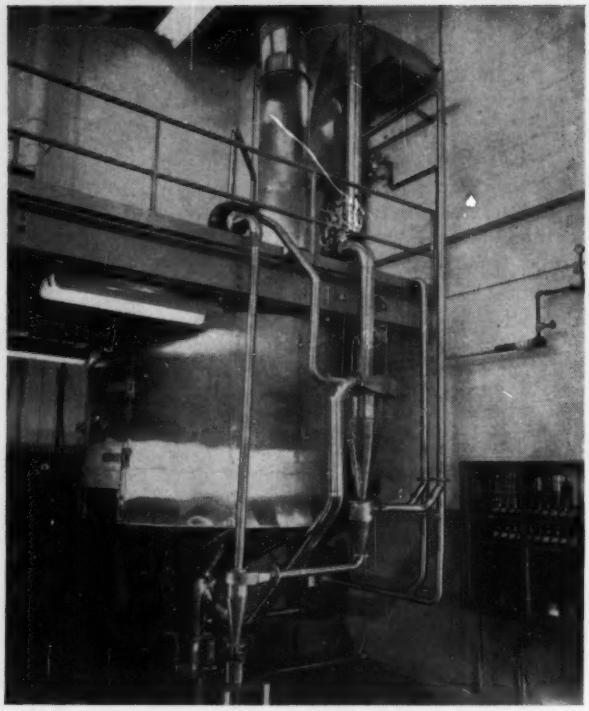
25 YEARS Dicalite 1930 1955

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DIVISION • GREAT LAKES CARBON CORPORATION, 612 SOUTH FLOWER STREET, LOS ANGELES 17, CALIFORNIA

ENDURO®

Stainless Steel Resists Corrosion, Protects Product Quality



Republic ENDURO Stainless Steel is the long-time friend of chemical engineers responsible for product purity and production. That's why stainless steel equipment was chosen for processing a relative newcomer to the chemical industry—concentrates.

Good examples of this type of equipment are the stainless steel spray dryer shown above and evaporator illustrated at right, manufactured by Rodney Hunt Machine Co., Orange, Massachusetts. The evaporators are used in the removal of methanol from certain nitrile compounds in the production of vitamins. Also for producing calcium pantothenate, a component of the vitamin-B complex. The spray dryer is operated in tandem with the evaporator to complete conversion from liquid to powder.

Quality and purity of the product are maintained because the material being processed comes in contact only with stainless steel. There is no danger of metallic contamination. ENDURO Stainless Steel is inert to most chemicals and chemical compounds. It does not add unwanted elements to chemical products. It never takes anything away. And it's so easy to clean and keep clean because it's solid stainless steel. There's no applied surface to chip, peel or wear away. ENDURO's hard, smooth surface offers little foothold for contaminants.

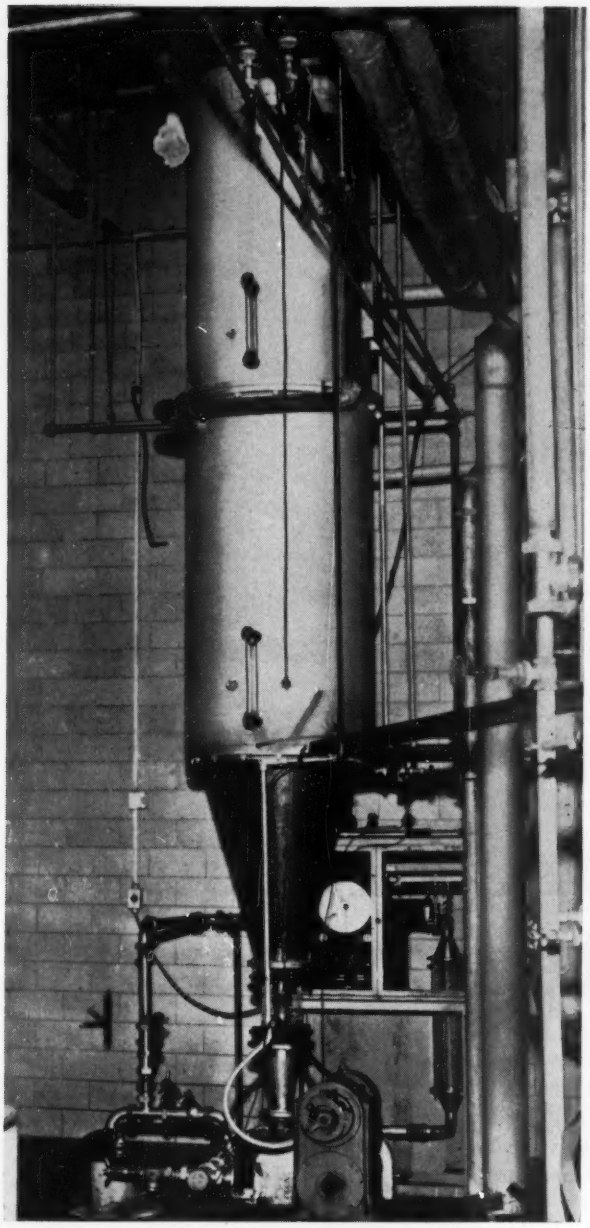
Strength, heat-resistance and corrosion-resistance are more advantages of ENDURO-made processing equipment like the evaporators and dryers mentioned above. These units, designed to operate at temperatures from below freezing to over 750°F, are made in thinner, lighter sections because of ENDURO's extremely high strength-to-weight ratio. And they hold their strength, toughness and corrosion-resistance all the way from below freezing to blistering heat.

Safeguard the purity and quality of your products by using equipment made from Republic ENDURO Stainless Steel. Ask your supplier for more facts. Or send coupon for additional information.

REPUBLIC

REPUBLIC STEEL

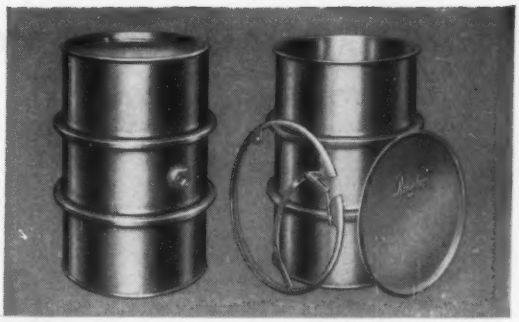
World's Widest Range of Standard Steels



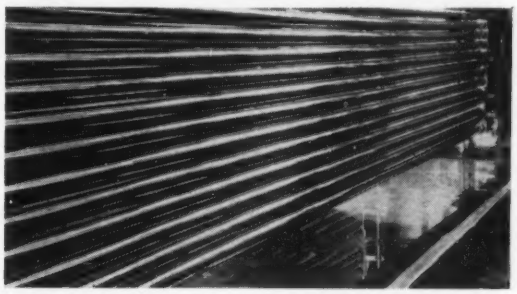
The Rodney Hunt Turba-Film Evaporator concentrates liquids continuously at a high rate of speed. Chemicals are condensed with the quality and purity preserved because the product has only a brief exposure to heat and only comes in contact with stainless steel.

STEEL

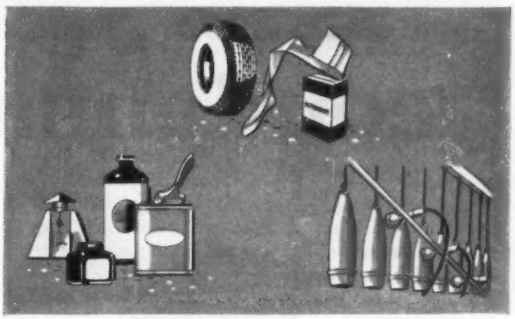
and Steel Products



MAINTAIN PURITY of your chemical products by shipping or storing them in drums and barrels made of ENDURO Stainless Steel. They'll give maximum protection against product contamination. ENDURO resists corrosion. Resists hard use and abuse. Never needs painting. Many styles to choose from in sizes up to 55 gallons.



CHEMICAL PRODUCTS receive positive protection against discoloration and contamination when transported through ELECTRUNITE® Stainless Steel Tubing and Pipe made by Republic's Steel and Tubes Division. ELECTRUNITE Stainless Steel Tubing and Pipe last years longer because they are corrosion-resistant and have a wide range of resistance to temperature, pressure and physical damage.



PURITY OF YOUR PRODUCT starts with the base chemicals. Republic is a basic producer of many chemicals derived from coal—benzols, toluols, xylols, sulphate of ammonia, tar, crude naphthalene, pyridine and crude heavy solvent. Like all Republic products, quality is controlled at every stage of production, from mine through coke oven, to final processing of the coal chemicals.

REPUBLIC STEEL CORPORATION
Dept. C-1027-A
3116 East 45th Street
Cleveland 27, Ohio

☐ Please send more information on ENDURO Stainless Steel for chemical processing
I am also interested in more information on:
☐ ENDURO Barrels and Drums ☐ Coal Chemicals
☐ ELECTRUNITE Stainless Steel Tubing & Pipe

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____



Nicholson *steam trap* capacity *gives you*...

faster, more effective condensate removal



Write, today, for your copy of new Bulletin 10-55—for detailed information.

Nicholson capacity is greater than that of any other trap of the same size. And, greater capacity—right across the board—means the Nicholson trap discharges condensate and air from chemical process steam lines and equipment *faster*, more *effectively*.

- **powerful valve action—big husky bellows.**
- **positive shut-off—finely ground valve and seat.**
- **high capacity—effective use of large orifice.**
- **each unit service tested—with steam.**

When less than the best won't do, specify Nicholson.

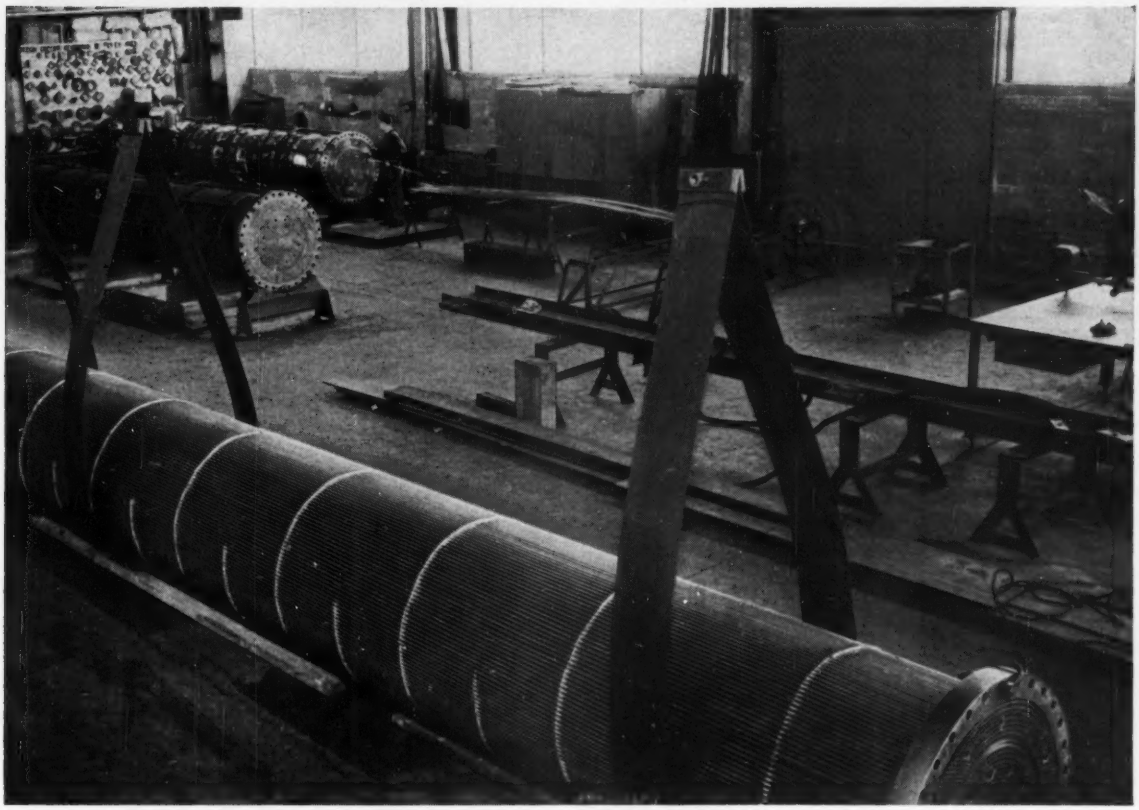
NICHOLSON

W. H. NICHOLSON and Company

TRAPS • VALVES • FLOATS • METAL PARTITIONS
LAUNDRY, DRY CLEANING AND PRESSING MACHINERY

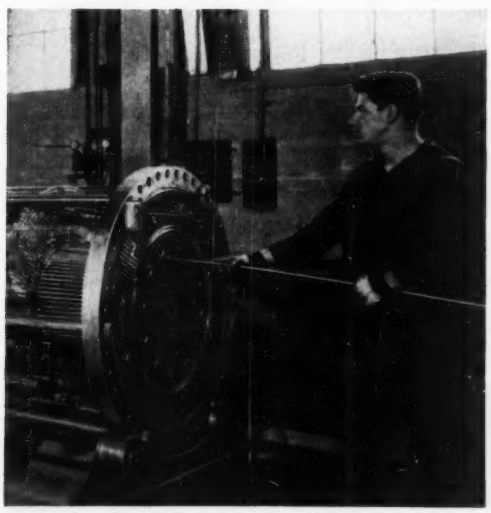
14 OREGON STREET, WILKES-BARRE, PA. • SALES AND ENGINEERING OFFICES IN 98 PRINCIPAL CITIES

From **86F** to **112F** Below



Tube bundles for huge heat exchangers used in the ammonia synthesis process. The baffles are of yellow brass.

Ten-ton tube bundle of Anaconda Copper does huge mixture cooling job in Heat Exchangers built by L'Air Liquide for ammonia synthesis plants



Anaconda copper tube being inserted in one of the heat exchangers at the Montreal plant of L'Air Liquide.

Straight-tube heat exchangers built recently by L'Air Liquide of Montreal as parts of the equipment separating gases, by low temperatures, for use in ammonia synthesis plants, imposed tough design conditions on materials. Gases enter the warm end at 86F; leave the cold end at −112F. Design pressure on the exchanger is 330 psi. Two of the exchangers are nearly 38 feet long. Each contains over 2000 lengths of ½" O.D. x .049" x 35' 4" Anaconda Deoxidized High Phosphorous Copper Tubing – weighing about 20,500 lb. A third exchanger is slightly smaller.

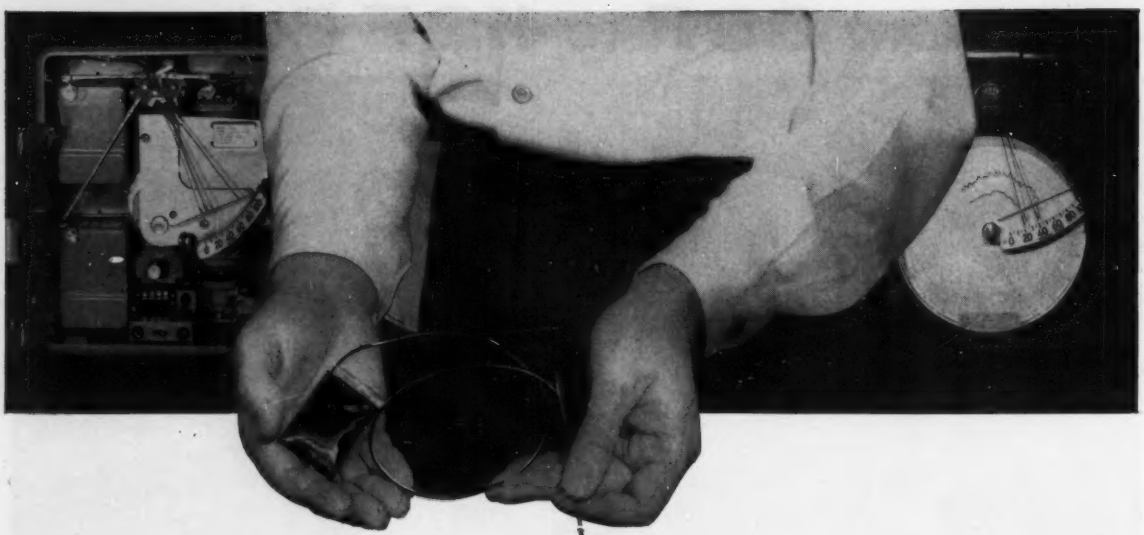
Anaconda Offers You Technical Service On Condensers And Heat Exchangers

No one tube material serves best under all conditions, but The American Brass Company has worked for many years with manufacturers and users of heat exchange equipment, helping solve many tough process problems.

The American Brass Company maintains special laboratory facilities for this work, keeps records of problems, conditions, findings. This experience and material can go to work for you. There is no charge for this technical service. Talk to your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

AB118

For efficient heat transfer **ANACONDA®** **HEAT EXCHANGER TUBES**



It's in the Bag!

Fresh, Clean Ink for a Year of Trouble-free Recording

★ You won't have any messy, time-consuming re-inking of pens on the new Bailey Recorders. The entire system is white-glove clean—hermetically sealed, non-evaporating, non-corrosive. Gone is any chance of sludge or oxide formation. Gone are clogged pens, interrupted records, unsightly splashes.

The transparent plastic ink sacs are changed once a year—that's all. Capillary tubing carries fresh, clean ink to the pens continuously without any day-to-day attention.

This exclusive new inking system* is only one of the many time-saving, money-saving distinctive features of the new Bailey Recorder.

Ask for Product Specification E12-5. P84-1

*Now available for the New Bailey Recorder only.

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

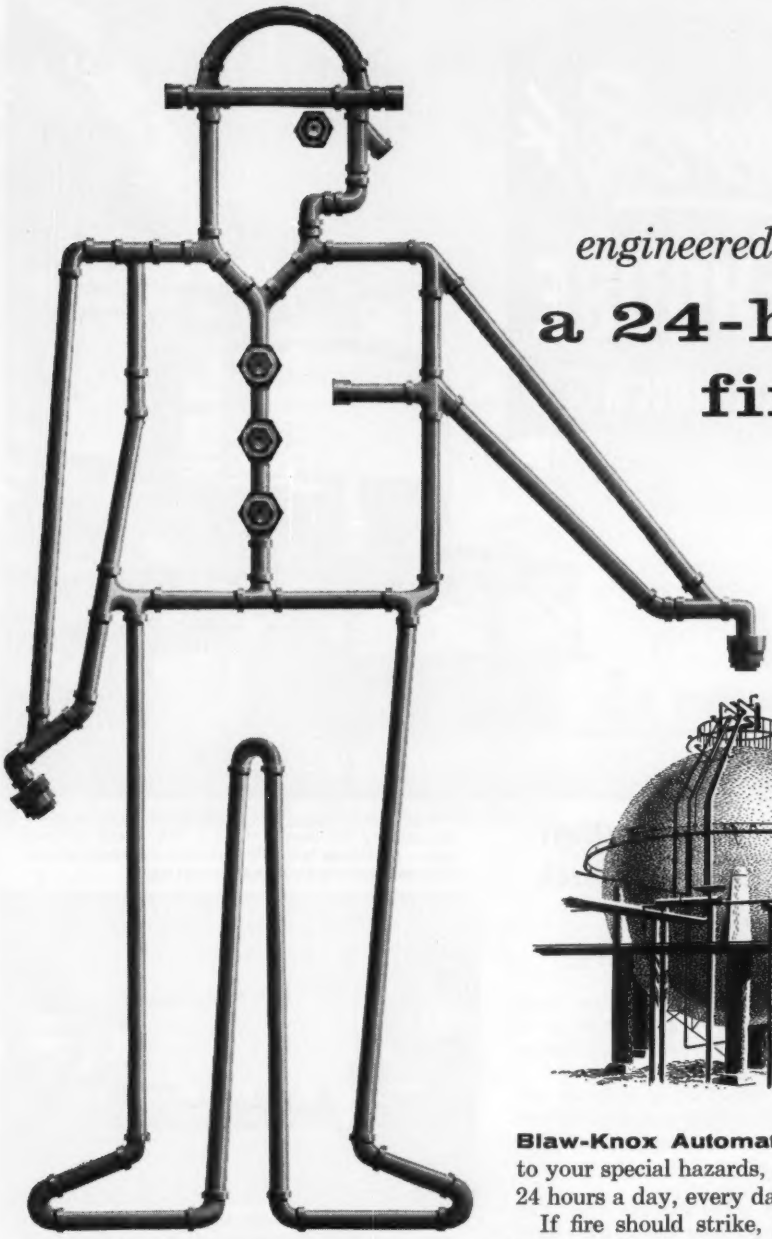
- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster ordering—from stock
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1054 IVANHOE ROAD
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Controls for Power and Process

BAILEY METER
Controls for
TEMPERATURE
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engineered by Blaw-Knox...

a 24-hour fire guard



Blaw-Knox fire protection systems carry approvals of all insurance underwriters.

• Deluge Systems • Wet Pipe Systems • Dry Pipe Systems • Water Spray and Fog Systems • Rate-of-Rise Sprinkler Systems • Foam and Carbon Dioxide Extinguisher Systems

Blaw-Knox Automatic Fog Systems, engineered to your special hazards, are fire guards that work for you 24 hours a day, every day in the year.

If fire should strike, your Blaw-Knox fire protection system will smother flames and dissipate heat quickly, thus checking possible loss of equipment and lives. It will also save you from such "hidden" dangers as loss of profits during downtime and loss of customers, possibly forever.

Blaw-Knox engineers have wide experience in water fog protection of chemical installations. We will gladly submit a layout and cost estimate of your requirements at no obligation. Why not call us today?

Send for a copy of our booklet, "Fire Can Destroy Your Business." You'll find it full of interesting facts.

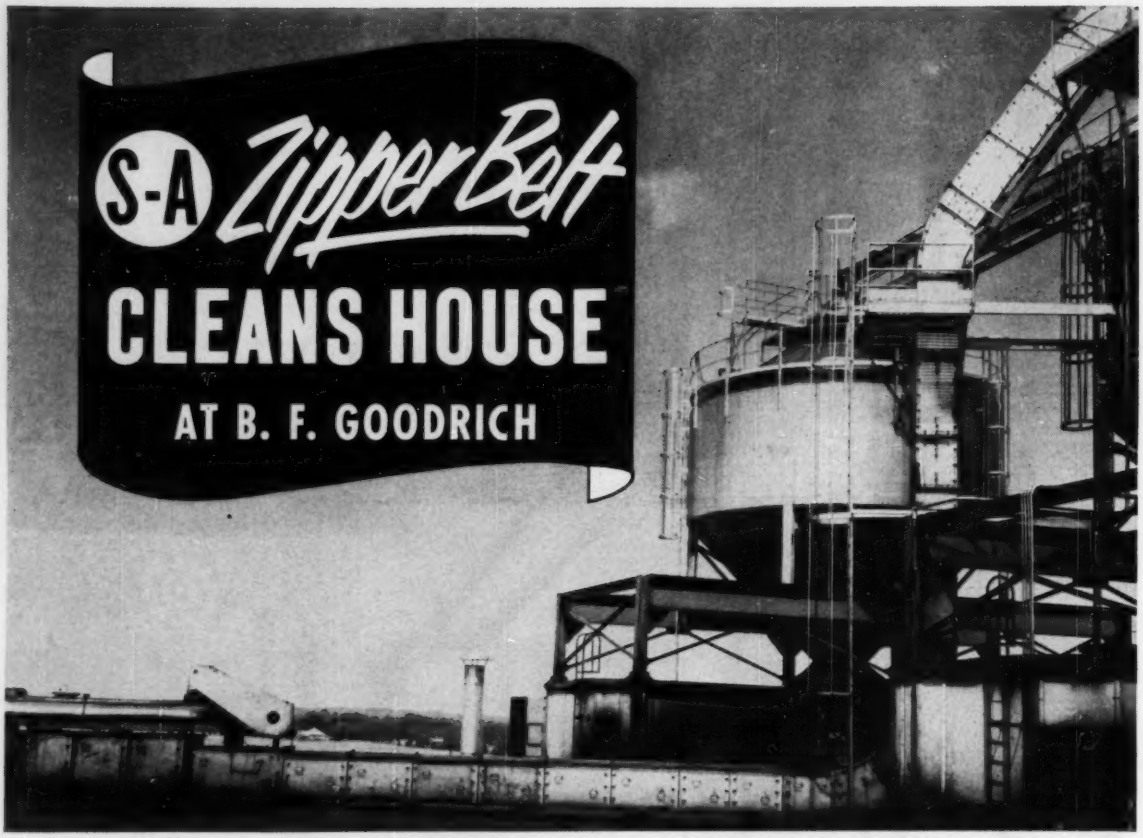


"Little Joey Sprinkler" always on the job

BLAW-KNOX

BLAW-KNOX COMPANY

Automatic Sprinkler Department / Pittsburgh 33, Pa.



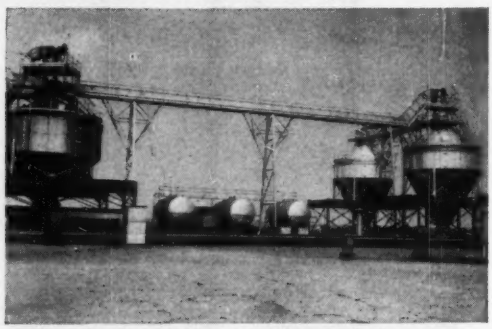
Degradation and dust are eliminated by handling carbon black with STEPHENS-ADAMSON Zipper-sealing belt conveyors.

To preserve the important but fragile structure of carbon black beads and at the same time eliminate dirt accumulation, B. F. Goodrich selected STEPHENS-ADAMSON "zip-in" conveyors for their Tuscaloosa, Alabama plant.

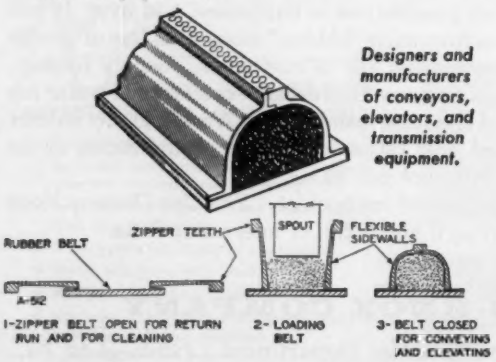
Completely enclosed and gently moved along at 9 tons per hour, carbon black travels horizontally, vertically and on inclined planes from feed to discharge. A very significant reduction in power consumption has been noted where screw type conveyors have been replaced with the S-A Zipper belt.

This installation is a direct result of the success which has been attained in Goodrich plants all over the country with similar equipment.

Enclosed in housing, this zipper conveyor runs 40 ft. horizontally and then 80 ft. on a vertical and inclined plane. Discharge is to either another horizontal zipper (see below) or to storage shown at right.



From elevator and storage section at left zipper conveyor runs 156 ft. horizontally, rises on an incline and discharges to additional storage facilities. Conveyor capacity—9½ tons per hour.



Designers and manufacturers of conveyors, elevators, and transmission equipment.

S-A engineering skill is solving hundreds of materials handling problems every year all over the world. This same talent can save you time and cost too.

STEPHENS-ADAMSON MFG. CO.
3 Ridgeway Avenue, Aurora, Ill.
Los Angeles, Calif.—Belleville, Ontario

ENGINEERING DIVISION
Designers and manufacturers of all types of bulk materials conveying systems.

STANDARD PRODUCTS DIVISION
A complete line of conveyor accessories—centrifugal loaders—car pullers—bin level controls, etc.

SEALMASTER DIVISION
A full line of industrial ball bearing units available in both standard and special housings.

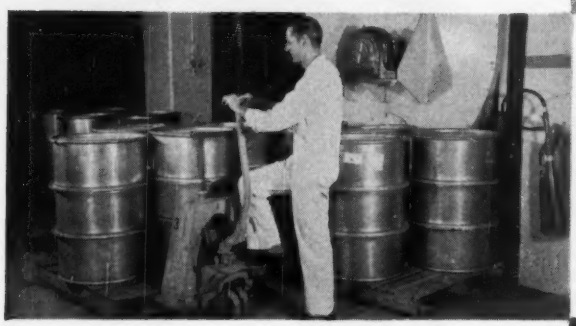
How Armco Stainless Steel can pack savings into containers you use

Armco makes more than 50 standard and special grades of stainless steel. Each has special properties for specific uses.

You'll find one or more of these Armco Stainless Steels can pack savings into the containers you use.

To find out how Armco Stainless Steels can help you cut your packaging and shipping costs, just fill in and mail the coupon.





Stainless steel resists corrosion. Armco Stainless assures long service in handling corrosive acids and chemicals. It is stainless all the way through—has no plating to wear off. And it can be fabricated into strong, durable truck tanks, drums and vats of all kinds for all types of service.

Armco Stainless Steel cuts replacement expenses. When your drums, vats and other containers are made of Armco Stainless they last longer—seldom need replacement. This corrosion-resistant steel is strong and extra tough. Containers look like new after years of use.

Stainless protects against contamination. In drug and food processing and other operations where sanitation is vital, stainless steel has proved its superiority. The hard and smooth surface of Armco Stainless Steel provides no hiding place for bacteria.

Lightweight stainless steel kegs and drums reduce shipping costs. And the strength of stainless guards against costly breakage. There's no need for extra protection of containers in transit. The hard, smooth surface of Armco Stainless Steel also makes cleaning a simple job.





ARMCO STEEL CORPORATION
1066 Curtis Street, Middletown, Ohio

Please tell me where we can obtain Armco Stainless Steel containers. We are interested in stainless containers of the following types and capacities:_____

Name_____
Company_____
Street_____
City_____ Zone____ State_____

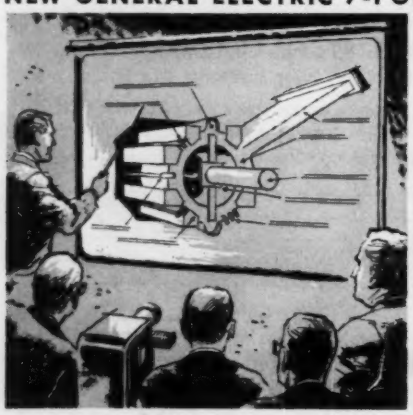
ARMCO STEEL CORPORATION
1066 CURTIS STREET, MIDDLETOWN, OHIO

ARMCO®

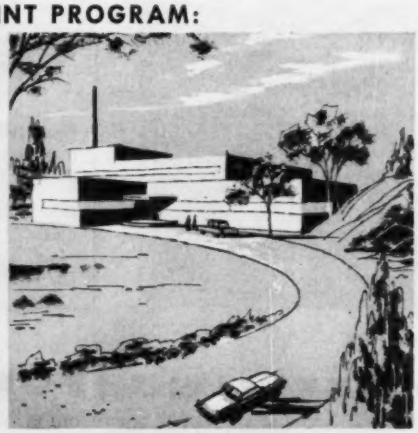
SHEFFIELD STEEL DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

SWIMMING POOL REACTOR, one of three G-E research reactors available under the 7-point program, is designed to produce large quantities of neutrons. Its flexibility, safety features, and high flux potential appeal to universities and research organizations.

NEW GENERAL ELECTRIC 7-POINT PROGRAM:



1 REACTOR SPECIFICATIONS are prepared to meet your research requirements. These include a report on core, control, and reactor components.



2 BUILDING STUDY also includes complete co-ordination of all plans for the many facilities required in the reactor and laboratory buildings.



3 HAZARDS SUMMARY REPORT: We help you prepare study for submission to AEC Division of Civilian Application.

How General Electric can help you enter advanced nuclear research fields

New G-E 7-point program simplifies procedure for obtaining a nuclear research reactor

There is more work involved in obtaining a nuclear reactor for advanced research than simply ordering one. Specific research requirements must be determined beforehand, an appropriate design selected, and necessary AEC construction permits and licenses obtained. Other essential steps are covered in the program outlined below.

NEW GENERAL ELECTRIC 7-POINT PROGRAM is a plan designed to materially aid you in putting a research reactor to work. Through this program you can obtain any one of three General Electric research reactors: The Swimming Pool Reactor, Heavy Water Research Reactor, or the Nuclear Test Reactor.

FOR MORE INFORMATION on these three research reactors and the new General Electric 7-point program, write for bulletin GEA-6326, General Electric Company, Section 191-1, Schenectady 5, N. Y.; or contact your nearest G-E Apparatus Sales Office. Outside the U. S. and Canada, write to: International General Electric Co., Inc., 570 Lexington Ave., New York, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC



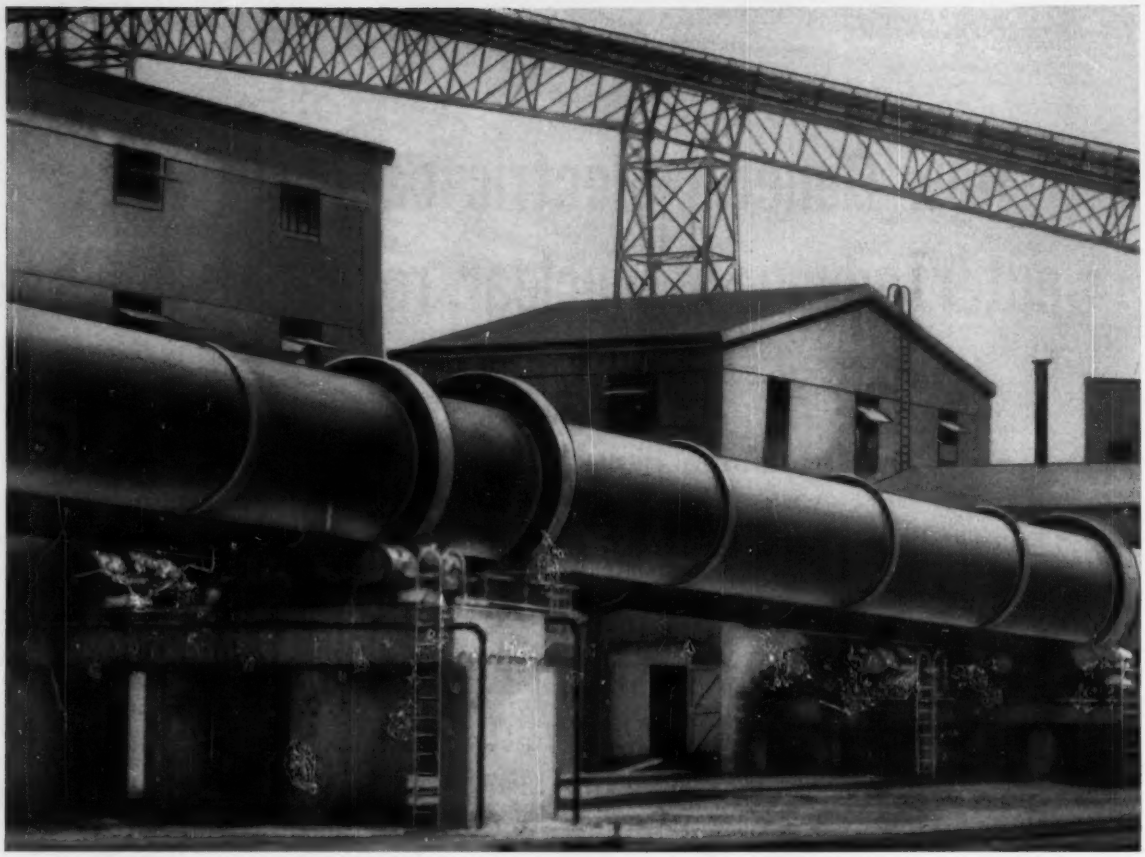
4 MANUFACTURE OF REACTOR is accurately co-ordinated with other construction plans, thereby assuring centralized project scheduling.



5 REACTOR INSTALLATION is completed at the site by the men who have followed the design and manufacture of the complete system.



6-7 START-UP AND SERVICE by experienced personnel is added assurance that proper operation of your nuclear system will be maintained.



LET THE LEADERS IN THE CHEMICAL PROCESSING INDUSTRIES HELP YOU SELECT A ROTARY KILN

Traylor Rotary Kilns are being used by leading producers the world over for calcining, roasting and chloridizing, volatilizing, sintering and nodulizing. Traylor Kilns have many exclusive features, developed as a result of actual field experience, which have earned them a universal reputation for extreme efficiency and rugged endurance.

Solid section steel riding rings of the full floating type are mounted on machined blocks to insure perfect fit. This special mounting holds them securely in place relative to the roller supports but permits them to float free of the shell as it contracts and expands. Traylor Kiln drives are completely mounted on a sole plate which is fully adjustable as a single unit . . . insuring perfect alignment and easy adjustment of main gear and pinion.

Traylor Rotary Kilns utilize secondary air to obtain maximum heat efficiency from every B.T.U. This Traylor feature achieves maximum thermo-processing economies. Another important feature is the individual consideration given to each installation. Every Traylor Kiln is especially made to fit the job it must do. Sizes have been made to 12′-0″ diameter and 450′-0″ long.

The universal acceptance of Traylor Rotary Kilns is best emphasized by the large number of customers who return time after time for additional Traylor Kilns. Before you buy your next kiln, do as so many of the world's leading producers have done . . . send for a copy of Bulletin 115 on Traylor Rotary Kilns.

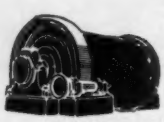
TRAYLOR ENGINEERING & MFG., CO.
841 MILL ST., ALLENTOWN, PA.
SALES OFFICES: New York • Chicago • San Francisco
Canadian Mfr: Canadian Vickers, Ltd., Montreal, P.Q.

A Traylor leads to greater profits


Primary Gyratory Crushers


Rotary Kilns


Secondary Gyratory Crushers

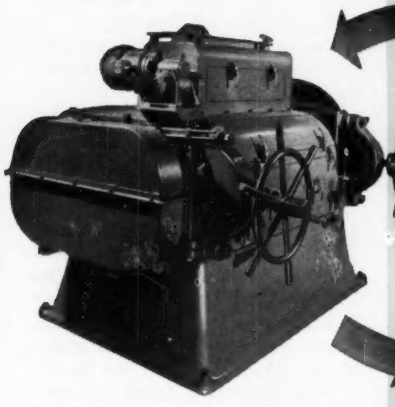

Ball Mills


Jaw Crushers


Apron Feeders

ALLIS-CHALMERS

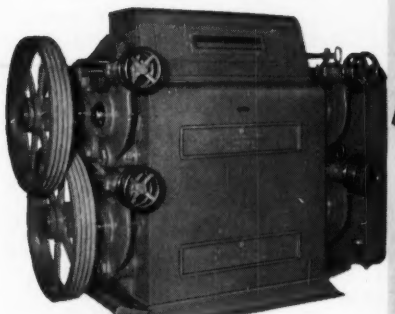
PROCESS SYSTEM Converts Fine Particles Into Granular Product To Meet Consumer Demand



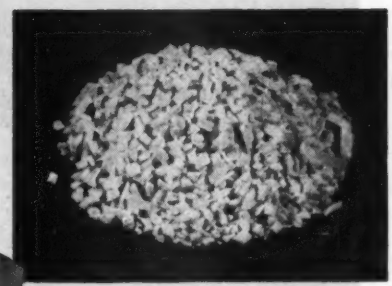
Compacting Mill

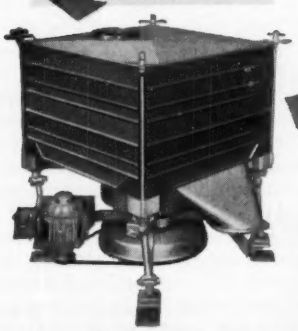






Roller Mill





Circle Sifter

1 Recovery operation starts with unacceptable minus 30 mesh chemical salt — fines created in original process.

2 An Allis-Chalmers heavy duty compacting mill is the principal component in the recovery system. The flakes or slabs illustrated are the result of mechanical densification in the compacting mill. An Allis-Chalmers two-pair high corrugated roller mill is used to granulate flakes. Final separation is made in the *Circle* sifter — an Allis-Chalmers gyratory screen. An 80% to 90% recovery of salable product is effected.

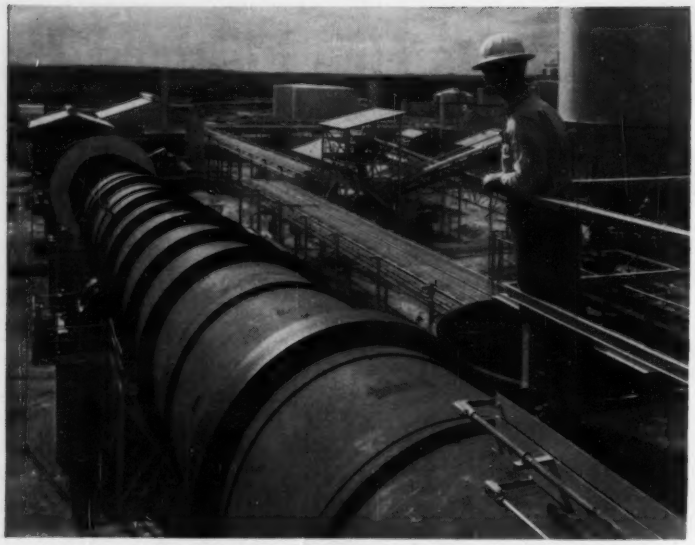
3 The resulting granules (100% minus 3 mesh and 100% on 10 mesh) equal or surpass natural product in every respect. Reconstituted product differs little from parent product in abrasion tests. Other tests have proved the compacted granule superior in controlled solubility. Granulated product is more uniform in particle size, flows more freely and has better "eye-appeal."

A-4743

For complete information, see your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 25C6177J.

Circle is an Allis-Chalmers trademark.

ALLIS-CHALMERS



PROCESS MAINSTAY: In 325-ft. kiln lithia converts to soluble form.

New Entry in LiOH Race

Process simplicity—via the alkaline route—is the keynote here as this new plant boosts U. S. LiOH capacity.

For lithium chemicals, one thing is certain: competition for the lithium dollar is getting keener every minute.

Laboratory curiosities a few years ago, Li chemicals are now turned out in ever increasing quantities. And adding to this growing production is American Lithium Chemicals' just completed $6.6 million alkaline-process LiOH plant at San Antonio, Tex. (For a description of the acid route see *Chem. Eng.* Feb. 1956, pp. 294-297.)

ALC (a subsidiary of American Potash) is the third producer to recently announce start-up of new facilities.*

Besides the market impact (no capacity figures have been released), two important technical features at San Antonio are attracting a lot of attention. They probably will influence the design of any new Li chemicals plants now on the drawing boards.

• **Ore supply.** African lepidolite ($LiF{\cdot}KF{\cdot}Al_2O_3{\cdot}3SiO_2$) is used. Foote Mineral, also depends on an alkaline route, but uses domestic spodumene ($Li_2O{\cdot}Al_2O_3{\cdot}4SiO_2$). Spodumene calls for higher kiln temperatures in the sintering step; forms a difficult-to-leach sinter.

• **Rotary kiln.** Here limestone is converted to lime, and this in turn converts alkalis in the lepidolite from insoluble lithium-fluoride-alumina-silicate complexes to soluble hydroxides. All other constituents are discharged as cement-like insoluble complexes.

▶ **Inside the Process**—ALC first feeds one part lepidolite containing 3.6 to 4% lithia with three parts Texas limestone ($CaCO_3$) to a ball mill. Both materials are crushed prior to ball milling to ¼-½ in. particles, and these are reduced to about 200 mesh by wet milling.

The 15% slurry from the mill is concentrated to 65% solids in a 100-ft. dia. thickener, then stored in twin storage tanks.

▶ **Making Sinters** — Thickened slurry goes to the 12 by 325-ft. rotary kiln. Material is retained for about four hours here, and discharges as ¼-in. sinters.

Quick quenching in strong liquor from the countercurrent leaching system (*see flowsheet*) keeps the lithia in soluble form and prevents phase changes in the lithia, alumina, silica alkali complex. The liquor also becomes the process leach liquor. This is all milled in a ball mill to 200 mesh, for leaching.

▶ **All Important: Leaching**—The purpose of leaching is to dissolve soluble hydroxides, and at San Antonio, it's carried out in two stages.

The first stage consists of two parallel lines made up of three tanks each, all held at 210 F.

From there, the slurry of lithium hydroxide solution and insoluble calcium, silicon and alumina goes to four countercurrent washer-thickeners. Underflow from the last thickener is leached in two tanks in series, then sent to rotary filters—filter wash is used as leach liquor. Overflow from the second thickener is the quench liquor for the kiln. Overflow from the first thickener goes forward through the process.

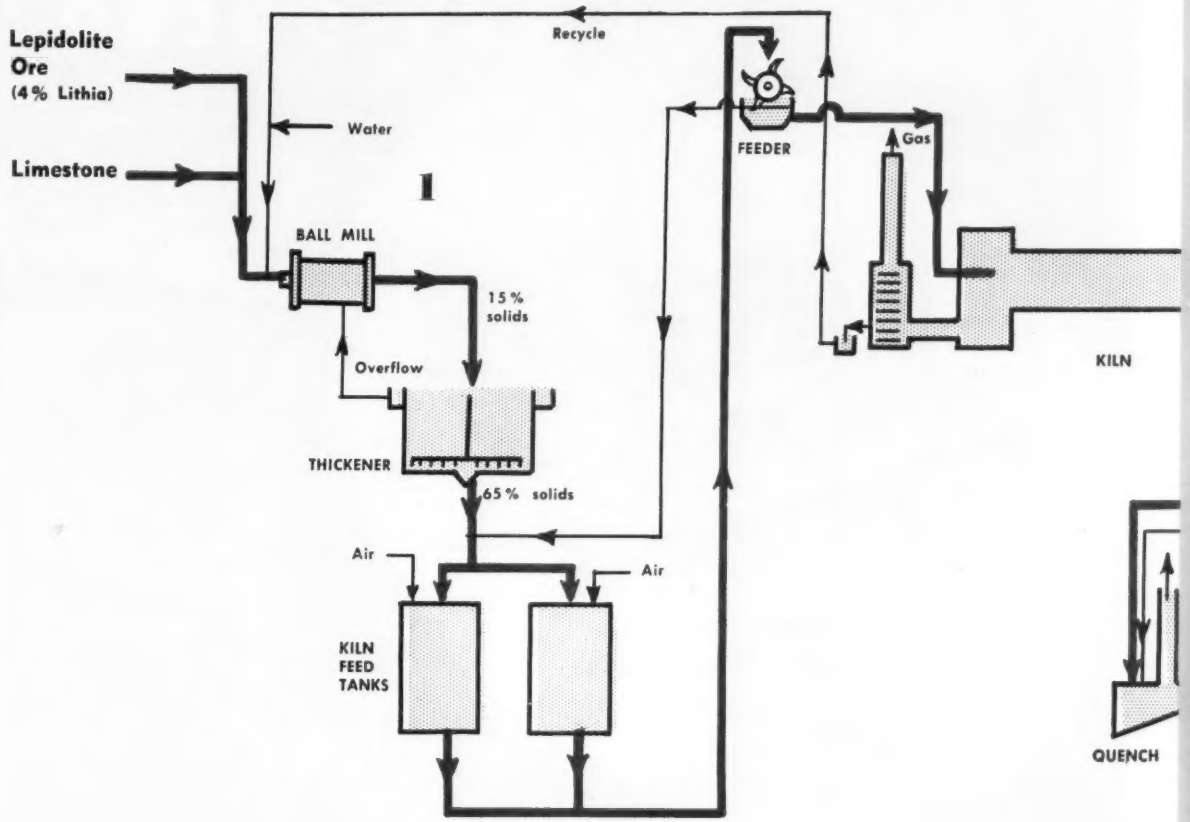
This overflow is first treated with milk of lime to remove any remaining Al_2O_3; filtered and the clear liquor sent to a triple-effect evaporator. Liquor at this point, is composed of lithium, potassium, rubidium, cesium and sodium hydroxides.

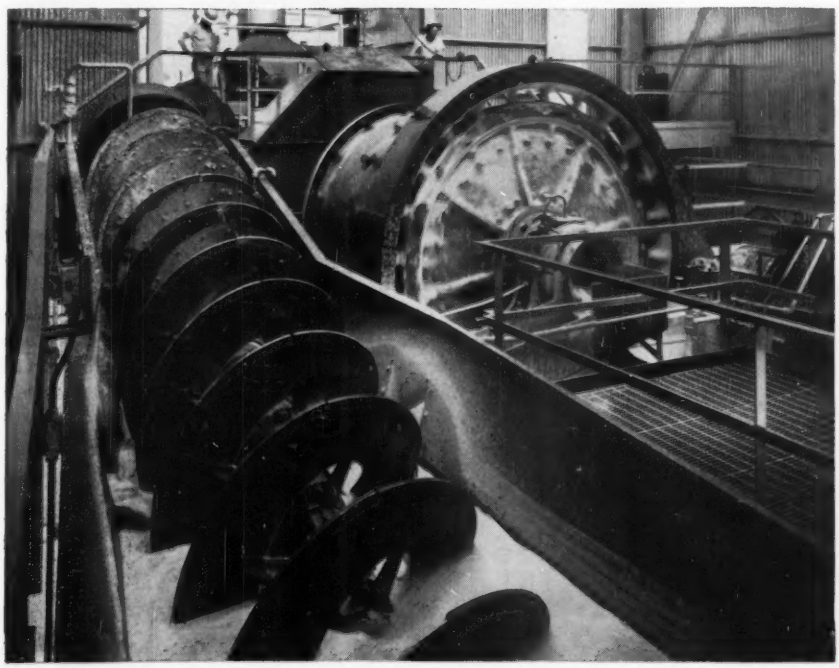
The effects are held at 250 F., 200 F., and 140 F., in that order. Last effect contains a slurry of lithium hydroxide monohydrate crystals.

▶ **Next, Purification** — This slurry is filtered on a continuous centrifuge. Crystals—which contain small quantities of impurities— are dissolved in water, then filtered through leaf filters. This time the filtrate goes to a vacuum crystallizer. Pure lithium hydroxide monohydrate is then centrifuged and dried.

Liquor from the continuous centrifuge is concentrated by submerged combustion. Lithium values remaining in the mother liquor are recovered as $LiCO_3$ by reaction with kiln gas.

* The other two: Foote Mineral and Lithium Corp. of America.

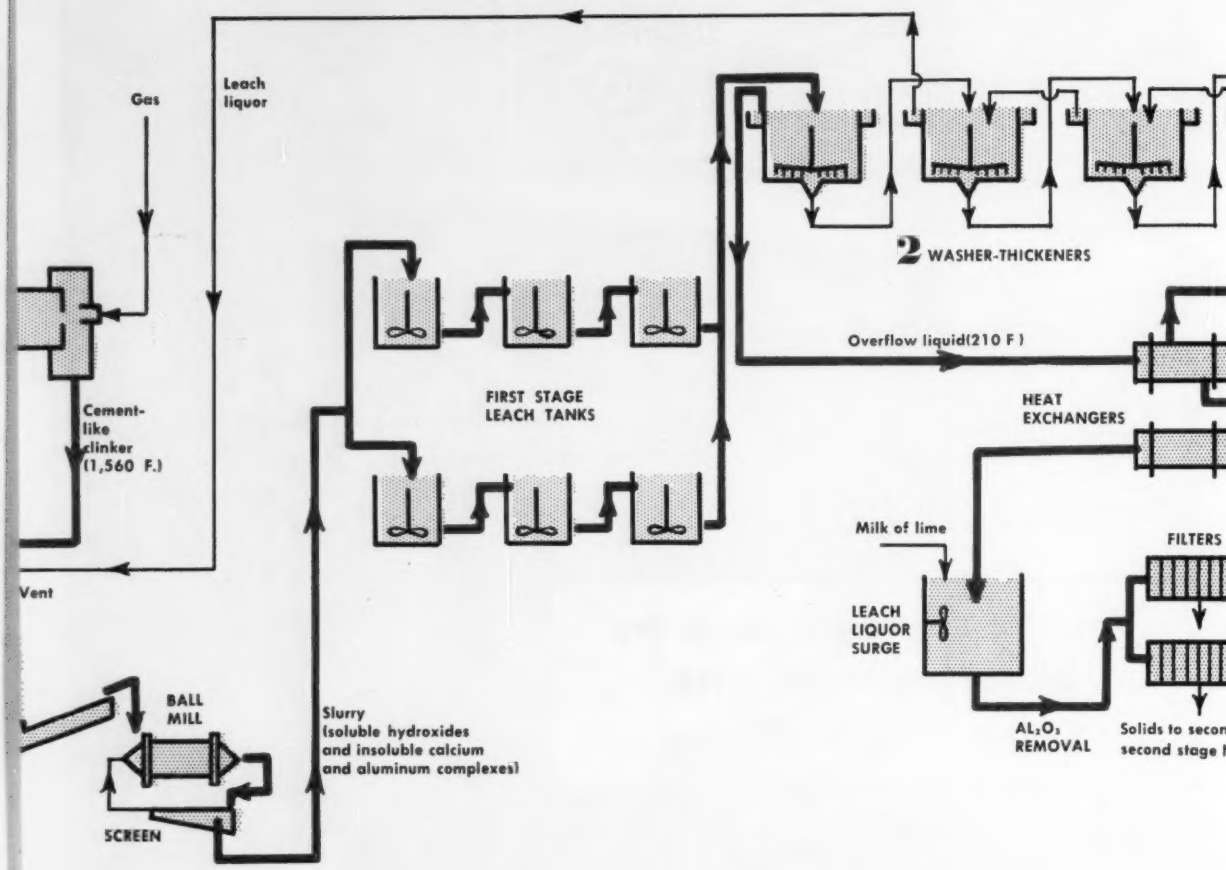


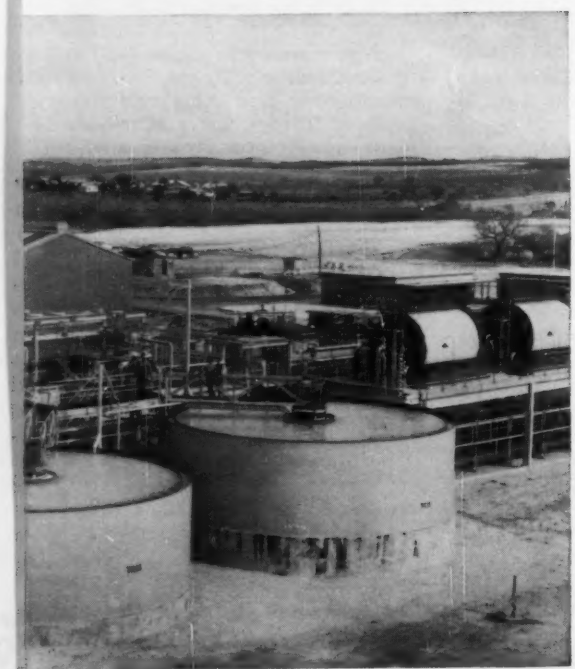


1 BALL MILL wet grinds three parts limestone and one part lepidolite ore to about 200 mesh in a 15% solids slurry, in preparation for the sintering operation.

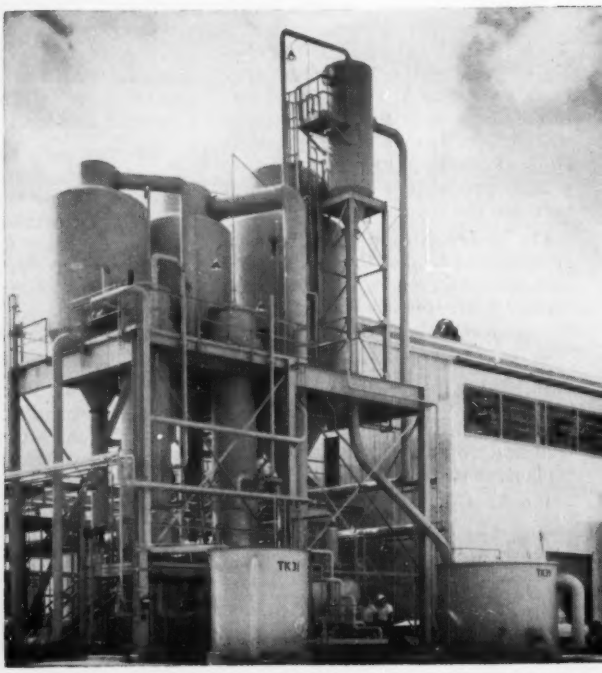


2 COUNTERCURRENT w
leached to dissolve hydr

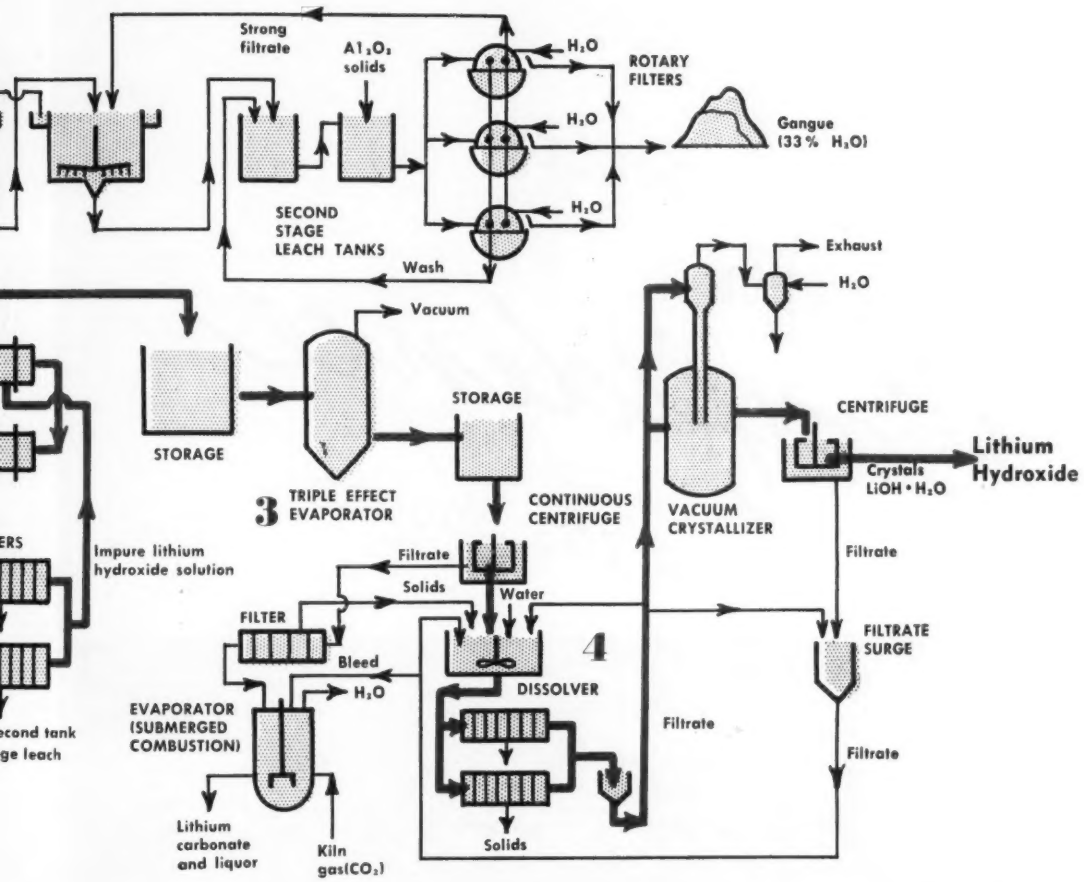




asher-thickeners handle the kiln discharge after it has been
xides. Drum filters (far right) take underflow.

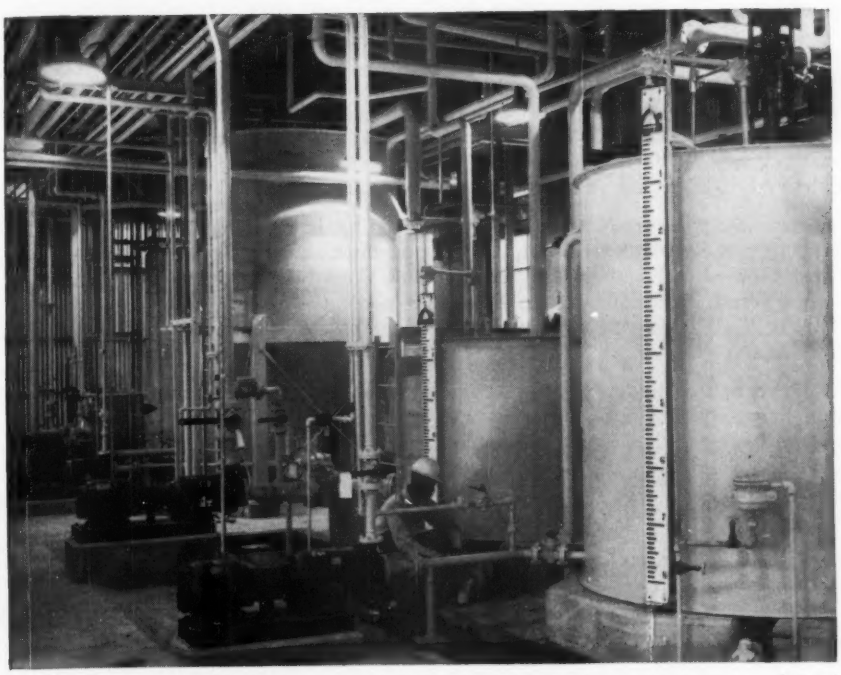


3 TRIPLE-EFFECT EVAPORATOR concentrates leach liquo
This liquor has been treated with milk of lime to remove





quor from the leach system. ve any remaining Al_2O_3.



4 IN DISSOLVING TANKS crystals from the triple-effect evaporator are heated with water. This solution is then clarified, crystallized and filtered.

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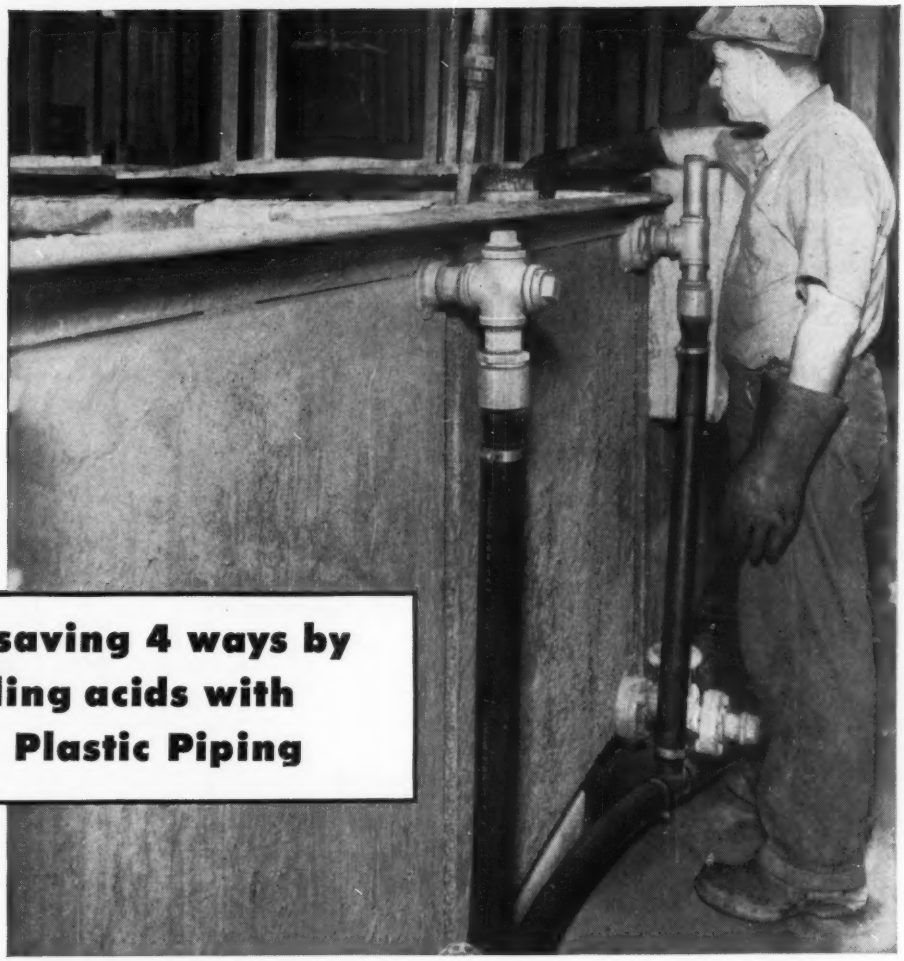


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They're saving 4 ways by handling acids with Crane Plastic Piping

THE CASE HISTORY— Globe-Union Inc., leading storage battery builder, in its Milwaukee plant, might have decided plastic piping wasn't for them and let it go at that. Instead, they gave Crane plastic products a fair trial, and here are the results.

On hydrochloric acid lines to zinc-plating tanks, the metal pipe and fittings formerly used had to be replaced completely about every month. Corrosion was the cause.

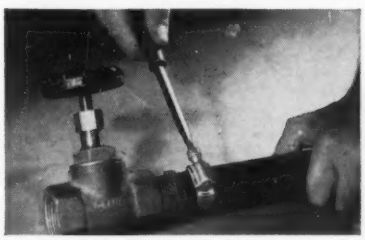
With Crane polyethylene pipe and Crane plastic fittings in this same service, after more than 3 months there is no sign of deterioration and no apparent need of early replacement.

On battery test tanks, Crane plastic piping, exposed to built-up sulphuric acid concentration, looks good as new after more than 4 months' service.

Savings with Crane plastic piping are adding up 4 ways. Plastic cancels the need for costlier metal pipe. It is installed in a fraction of the time it takes for metal pipe and fittings. It reduces installation to a one-man job with simple hand tools. The longer life of plastic is saving replacement, maintenance and housekeeping costs.

Proved in severest services, Crane plastic piping is giving Globe-Union equal satisfaction on many low-pressure air and water lines. Here freedom from sweating is another advantage of plastic.

Once you know the facts of quality-designed, quality-made Crane polyethylene pipe and Crane plastic insert fittings, you, too, will see many opportunities for saving with this modern piping. Call your local Crane Representative today, or write to address below.



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For further details, sizes and uses, see Bulletin #80.

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EDITED BY M. A. GIBBONS

H. Seymour Colton: Man of the Month

Enterprising chemical engineer, who quit one presidency to take on another, has flare for making a go of new business ventures.



President of Colton Chemical Co. (Cleveland) since its outset, H. Seymour Colton has resigned his position to accept another—as president of Macco Chemical.

That's the way the announcement reads but there's lots more that can't be left for footnotes.

Here's a man who's happiest when he has to anwer for most of the risks himself. He has a flare for trying out new things, bucking the responsibility and seeing his brainchildren grow and develop.

The Colton Chemical venture began in 1943. Colton and two associates founded the firm that bears his name, late that year. With Colton as president, sales for its polyvinyl alcohol and emulsions output climbed into the multi-million dollar class last year.

Two years ago, after Air Reduction bought the firm for 114,000 shares of stock ($25/share, in 1954), its president stayed on.

▶**Free Rein**—Colton, however, is a fairly rugged individualist: while on his own only his banker could possibly question his business moves. And this is not exactly the case today with Air Reduction—nor does anyone expect it to be so.

And so, Colton now has a yen to develop Macco. He already has six or eight projects lined up, a few of which he expects to result in new products before long. Just now, they're still in the "think" stage but we know this much: they're in the fields closely related to chemicals and plastics. (To date, Macco turns out water emulsion and oil based mastics for plastics tile settings.)

Besides new product development, Colton's plans for Macco include acquisition of small chemical companies which turn out related products. So far, he's busy scrutinizing the three or four dozen applicants which are already banging on his office door.

To date, he plans on financing operations himself, though dozens of investors—aware of his financial success—would just as soon have a chunk of Macco right now.

No stranger at Macco, Colton had a hand in organizing the firm seven years ago. (Today, he and five associates own it.) And, this is a good time for him to take a more active part in view of the ill health of a partner (McCarton).

Chores at Macco, Colton thinks, will demand a good two-thirds of his time. For the rest he'll offer his services as consultant in chemical and polymer enterprises.

▶**Case History**—Probably no one will raise eyebrows at the high goals Colton has set for Macco. Not, at least, after a glance at the success of his past ventures.

Take a look at the pre-history of Colton Chemical. Back in 1940, Colton was still a consulting engineer, handling such accounts as Cosma Laboratories Co. After absorbing a controlling interest, Colton developed various polyvinyl acetate emulsion products on his own. A few year later, in order to commercialize them, he formed the Special Chemicals Co.—predecessor to Colton Chemical.

From here on Colton was off to the races.

▶**Earlier Case in Point**—Another good example of Colton's enterprising nature dates back about twenty years. Early in his consulting career, he developed a process to transform waste pickling liquor into a building material. (*Chem. Eng.*, August 1938, p. 430.)

Here at last was a means of doing something useful with a by-product that, to date, had only offered disposal headaches: Pickling liquor—though largely a saturated solution of ferrous sulfate—usually contains several percent of free sulfuric acid.

When ejected into local streams, it not only makes survival for natural life difficult but also corrodes any metals it contacts. Neutralizing the liquor with lime fails when hydrolysis slowly returns it to its corrosive original status. Conversion into copperas works but here world consumption demands aren't exactly overwhelming.

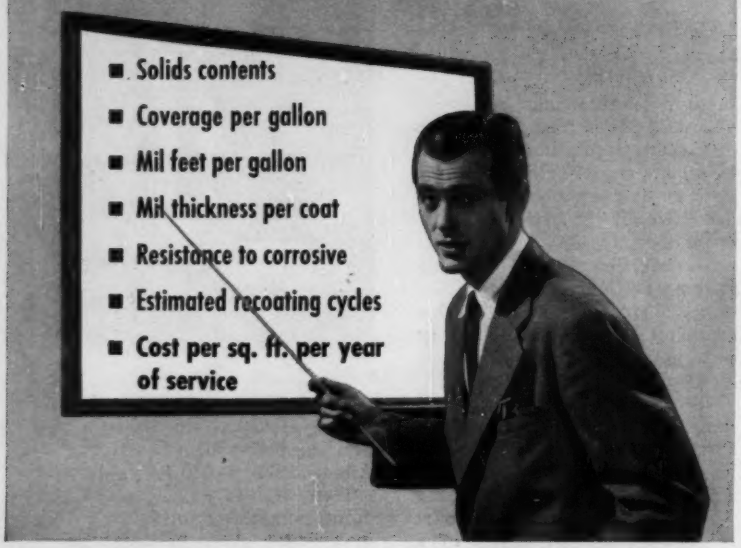
Colton's new material—*Ferron*—was a co-precipitated iron oxide and calcium sulfate. Its value as a building material stacks up like this: Though porous, it's a good insulator. During manufacture it is extremely plastic but later hardens rigidly in any desire shape. Though it resembles wood in many ways, it resists warp, fire and even termites. Besides it is rather inexpensive and the amount of capital required for equipment is small.

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ping up a chemical engineering degree at MIT, Colton tried his hand at baseball. In fact, he became adept enough to make the team of a semi-pro league.

Of course, at 55, he's still not swinging the bat. In fact, he lost interest in the diamond some years ago. But since untried ventures are nothing new for him, he tried other fields.

1956 finds him among those who can jump the net (or so the legend goes) after a few sets of tennis, not exactly inept as a figure skater and a bit skilled as a salt water fisherman. And, it's only a few years since he gave up competing in badminton tournaments.

Colton and his wife have a modest home in one of Cleveland's residential suburbs. Their two sons and two daughters are married now, but Colton takes a grandfather's usual delight in his seven grandchildren.

▶ **Background**—Post-MIT days were first spent as chief chemist at one of New Jersey Zinc's plants. Later with Tubize-Chatillon Corp., he helped develop and put to use a process for the manufacture of sodium hydrosulfide—a chemical largely imported from Germany at the time.

A few years later, he joined Krebs Pigment & Chemical as assistant technical director and then transferred to Du Pont's Grasselli Chemical Div. to work on new product development.

Then, in the mid-thirties he took on his own consulting practice.

For the past 25 years, Colton has been a member of the AIChE. More recently, his name appeared with those associated with the ACS and the American Assn. for the Advancement of Science.

Lawrence N. Canjar, Assoc. Professor of chemical engineering at Carnegie Tech, has received one of the School's teaching awards for 1955.

A. P. Moss has been appointed industrial chemicals production manager and **Max Hill** is fine chemicals production manager at Carbide & Carbon Chemicals.

H. C. Howell has been appointed chief chemist for technical development of Pioneer Products Div., at Witco Chemical.

Roy N. Dickinson has joined the staff of Roger Williams Technical & Economic Services, Inc., New York.

Jay C. Searer and **Lother A. Sontag** have been promoted to production manager and technical manager at Hooker Electrochemical's Durez Plastics Div.

Carl A. Bennett became manager of GE's operations research section at the Hanford atomic plant near Richland, Wash.

John H. MacDonald, former consultant for Nepera Chemical Co. and the Anahist Co., has been selected manager of their Harriman, N. Y., plant.

Fred Lohse has been appointed technical asst. to the manager of the chemicals div. of Kaiser Aluminum & Chemical.

A. R. Dudley has been promoted to senior chemical engineer at Humble Oil's Baytown, Tex., refinery.

R. R. Zisette has been elected a director and vice president-general manager of Jessall Plastics Inc.; **R. S. Jesionowski,** founder of the firm, is now a vice president and director.

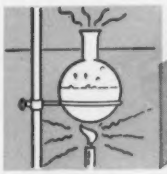
Alfred F. Bauer has been appointed asst. general manager of the Doehler-Jarvic Div. of National Lead Co.

Lyle Lovell has been promoted to group leader, technical service div., American Oil Co., Texas City, Tex.

Herbert H. Schmiel has been named chief engineer of the industrial hydraulics div. of Parker Appliance Co.

Harry F. Ahern has been promoted to asst. director of

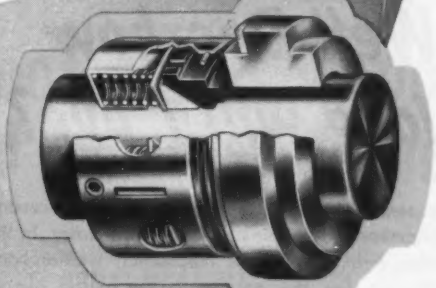

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NAMES . . .

operations of Hercules Powder's synthetics dept.; **John Miller** is manager of engineering; **Harold R. Monfort** is manager of the Mansfield, Mass., plant.

Richard Dodson has been awarded the AEC's certificate of appreciation for his services as secretary to the Gen'l Advisory Committee. Dr. Dodson is chairman of chemistry at the Brookhaven Nat'l Laboratory.

Merrill Weymouth will now manage Dow Chemical's Ironton, O., plant; **Robert Reinker** will manage the Riverside plant at Pevely, Mo.

Thomas E. Deger has been advanced to the position of acting director of organic research at Pennsalt.

H. K. Intemann has been appointed executive vice-president of Electro Metallurgical Co., div. of Union Carbide.

Jacques L. Zakin, senior research technologist with Soconey Mobil Oil, has been named winner of the firm's 1956 Incentive Fellowship Award.

John Hawkins and **Tung Liu** have joined the staff of the chemical research dept. at Monsanto's research & engineering div., in Dayton, Ohio.

Norbert S. Mason has joined the staff of the B. F. Goodrich Co., research center, in Brecksville, Ohio.

Carl Bordenca, head of the organic chemical div. and asst. director of Southern Research Institute, will join Newport Industries, Inc., as asst. to the president.

Walter J. Kaufman has been appointed manager of Watson-Standard's technical div.

F. O. Robitschek has been selected president and chief executive officer of Onyx Oil & Chemical Co., Jersey City, N. J.



Harry B. McClure

Carbide & Carbon's president —Harry B. McClure—received honorary membership in the AIChE, at a dinner meeting at the Hotel Commodore, January 12th.

McClure has spent nearly all of his professional career at Carbide. Following his first position as a research fellow at Mellon Institute, he has served successively as manager of the fine chemicals div., vice-president and executive vice-president. In 1954, he became the firm's president.

During his career, McClure has concentrated on the development of new chemicals and their uses.

Lee P. Morris, an official of Standard Oil of Calif., is the new manager of operations for American Gilsonite's $13 million coke-refining plant to be built at Fruita, Colo.

Robert T. Sheen has been elected president for 1956 of the Instrument Society of America.

Ernest Guenther, perfumer and chemist, became the 8th recipient of the Society of Cosmetic Chemists' annual medal.

Ben W. Wilson has been elected vice-president in charge of mfg. for the Doughnut Corp. of America.

Sewall D. Andrews, Jr., has been appointed general manager of General Mills' soybean division.

Carl A. Bennett has been named manager of GE's operations

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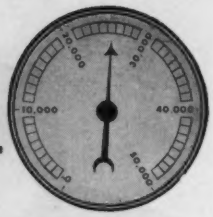
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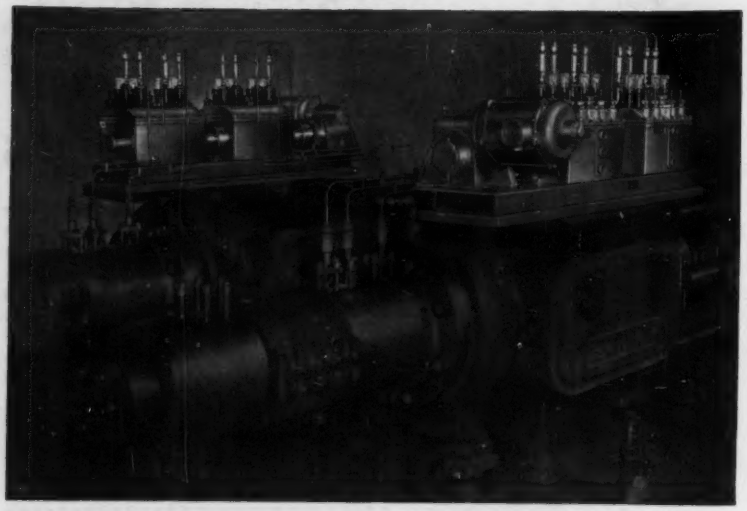
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NAMES . . .

research section at the Hanford Atomic plant. The plant's new manager of engineering is **O. H. Greager.**

George Patterson is Hooker Electrochemical's plant engineer at the Durez Plastics div.'s No. Tonawanda plant. **Peter Casella** is now manager of the patent section, at Niagara Falls.

John T. Moore will retire from Hercules Powder's explosives dept. after 40 years of service. **George H. Ripley** is the new project engineer at the Wilmington engineering dept.

Robert Doonan has joined the staff at Hammond Iron Works.

Robert B. MacMullin has received the AIChE professional achievement award for the Western N. Y. section.

F. H. Mulligan, leader in the powder metallurgy field for the past 20 years, is now president of Charles Hardy, Inc.

Bernard Jones has been appointed to the newly created position of chief engineer for the Crucible Steel Co. of America.

George T. Paul has joined the International Nickel Co. as a member of the development and research division's corrosion engineering section in New York.

J. T. Higgins has been appointed assistant general manager of the mfg. dept. of Standard Oil of Calif.

George Diehlman has been selected manager of the pigments and chemicals division of Nat'l Lead's Atlantic branch.

E. F. Schroeder is the new vice president in charge of mfg. for Corn Products Refining Co., in New York.

Irving Abrams has been promoted to the position of associate technical director of

Chemical Process Co., San Francisco.

Gerard C. Heldrich, Sr. has been appointed technical service director of Grace Chemical Research & Development Co. Heldrich has had 18 years experience in the plastic industry.

James F. Roe has been promoted to manager of the Florida operations of the phosphate chemicals div. of International Minerals & Chemical Corp.; **Charles A. White** has been advanced to manager of the division's Tennessee operations.

Paul F. Hand is the new assistant to the president of General Aniline & Film Corp.

Robert H. Malott is the new assistant to the president of Niagara Chemical of Food Machinery & Chemical.

Max A. Minnig has been elected president of Witco Chemical to succeed **Robert Wishnick,** now chairman of the board and chief executive officer.

Robert M. Rodgers has joined Olin Mathieson Chemical in Niagara Falls, N. Y.

Virgil A. Moore has retired after 26 years of service with American Cyanamid, in various capacities.

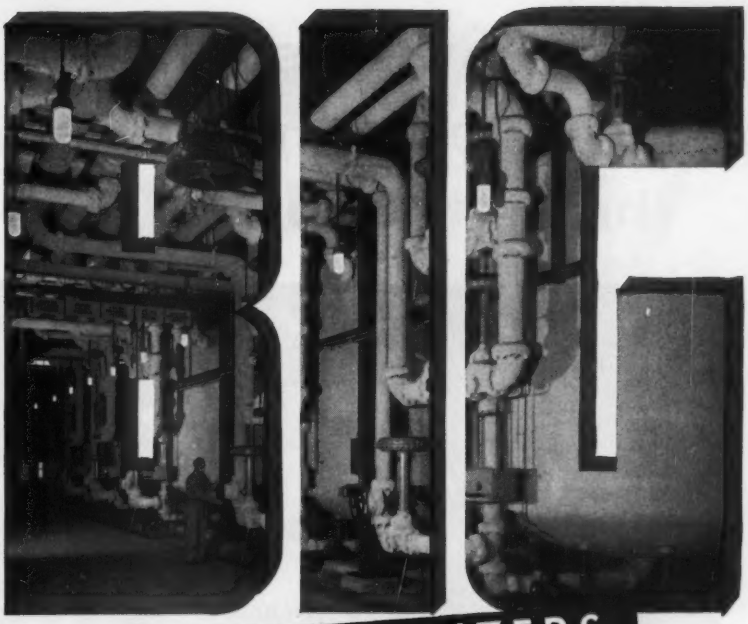
W. G. Frank, formerly executive vice president of American Air Filter Co., is now the firm's president.

Fred Sheldon has been named manager of Becco Chemical's pulp and paper research & development dept.

W. L. Banks has joined the Davison Chemical Co.'s petroleum catalyst dept.

Keith Conrad has been promoted to chief engineer of the Pacific coast div. of Owens-Illinois Glass Co.

Donald G. Sturges, formerly director of operations of the AEC's plutonium plant in



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THIS demineralizer, one of the world's largest, provides 100% makeup for 1250 psi boilers generating 1,200,000 pounds of steam per hour. Using Nalco ion exchange resins, Nalcite HCR® and Nalcite SAR, silica is successfully removed from the feedwater—as illustrated by the fact that after 75 to 100 concentrations, silica content of the boiler water is still *less than 5 ppm!*

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DATA ON SILICA REMOVAL

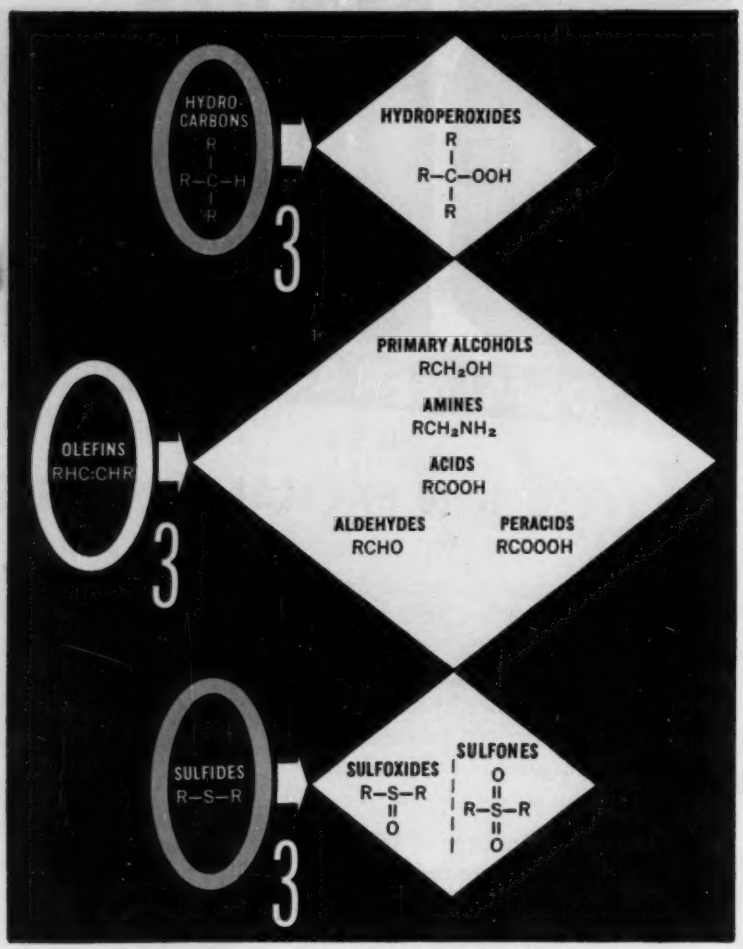
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NAMES . . .

Washington State, has been appointed manager of the new products branch of Carborundum's research and development div.

Donald Sheffield has been named asst. general manager of Hercules Powder's synthetics dept.

Donald Gilman has been appointed vice president and treasurer of the Warren Steam Pump Co.

John Sherred is the new director of development at Lion Oil Co. He had served as director of research at Monsanto's plastics division. **H. Bible** is director of mfg. at the firm's El Dorado refinery.

Luther R. Hill, former president of Process Designs, Inc., has joined Arthur G. McKee & Co. as process coordinator of the petroleum division.

Leslie E. Simon, retired Major General, U. S. Army, has been appointed director of Carborundum's research and development division.

D. N. Rindsberg has been appointed asst. supt., technical, at Shell Chemical's Houston plant. **J. B. Wyman** is supt. of Shell Oil's Anacortes refinery.

W. T. Thagard, III, is the new director of plans and economic research for Texas Eastern Transmission Corp.

Bernard C. Barton has been selected director of research and development for Texas-U. S. Chemical Co.

Louis Munchmeyer has been appointed asst. general manager of Wyandotte's Michigan Alkali div.

Raymond W. Jacoby, consultant with Ciba Co., Inc., has been reelected president of the American Assn. of Textile Chemists and Colorists.

Graham B. Knight, formerly associated with Stone & Webster's Badger Process div.,

has joined **Jos. R. Minevitch** in his Boston chemical engineering consultation practice.

John W. Nee, Briner Paint Mfg. Co., is the 1956 chairman of the so. central region, Nat'l. Assn. of Corrosion Engineers. **Harry E. Waldrip,** Gulf Oil Corp., has been elected director for the same region.

Paul W. Gann and **Samuel Mosley** have been transferred from the research & development dept. of Chemstrand's acrilan plant technical dept., as asst. technical supt. and process assistance supervisor.

Edward R. Scammell, former supt. of Consolidated Mining's Trail, B. C., fertilizer plant, has been named Garfield plant manager for Western Phosphates, Inc.

John Moynihan has been appointed basic research supervisor for Acheson Dispersed Pigments.

E. T. Casler has been promoted to manager of the Florida operations of the Phosphate Minerals Div. of International Minerals & Chemical Corp.

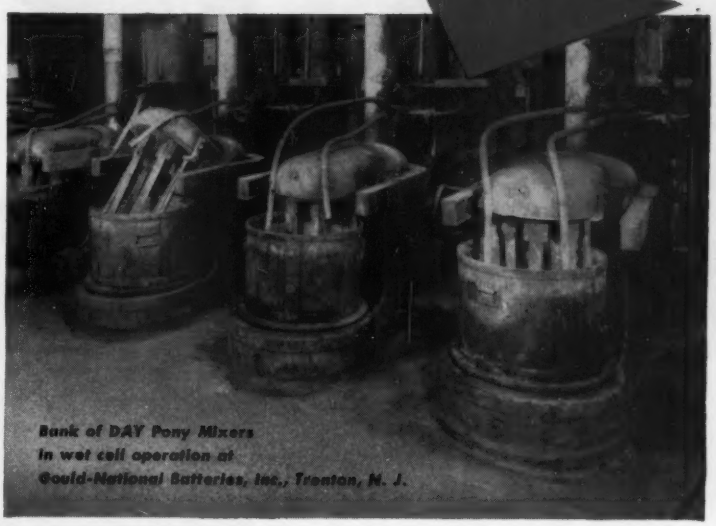
Hans Z. Lecher has entered the consulting field, in New Jersey, specializing in synthetic organic dyes and intermediates.

J. L. Whiteside is manager of Monsanto's elemental phosphorus plant in Monsanto, Tenn. **Charles Smith** is now general mfg. supt. and **Wm. Dougherty** is a new member of the technical services dept. at the John F. Queeny plant in St. Louis.

Allen Erdman, Charles Knight, John Swan are Monsanto's new general superintendents of mfg., maintenance, and staff services, respectively. **David Miller** has rejoined the engineering research department in Dayton, Ohio.

Carl R. Addinall has joined R. S. Aries & Associates, a New York consulting firm. He had completed 25 years

it paid to buy DAY



Bank of DAY Pony Mixers in wet cell operation at Gould-National Batteries, Inc., Trenton, N. J.

GOULD-NATIONAL BATTERIES, INC. now blends 250 lbs. of heavy paste in 25 minutes in a DAY PONY MIXER.

Considerable production cost savings have been achieved by this outstanding Company using DAY Pony Mixers. Despite the fact that the product being mixed is very heavy and highly acid, operation is virtually trouble-free.

There are no bearings or stuffing boxes in the product zone. Extra rugged construction assures absolute rigidity. Planetary mixing action plus agitator blade contouring, delivers radial and lifting mixing over entire depth of can.

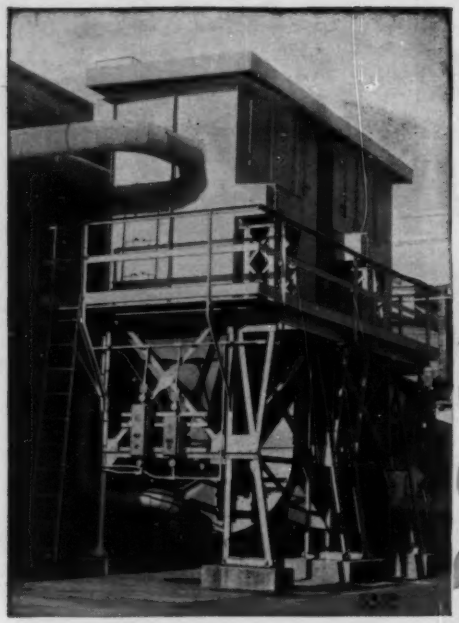
It will pay you to investigate the increased production plus cost savings you will receive with DAY mixers. Write for Bulletin 500.

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Quality equipment for baking, paint and varnish, printing ink, chemical, rubber, pharmaceutical, cosmetics, paper and pulp, explosives, food, ceramics, candy, soap, sugar and milk products.

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Sly Dust Filter at the plant of Merck & Co., Inc., Rahway, New Jersey.

SLY KEEPS VITAMIN PLANT DUST-FREE



Packaging Unit showing exhaust duct connected to Sly Dust Filter.

Merck & Co., Inc. uses Sly Dust Filters to maintain quality of product and manufacturing efficiency in the processing of vitamin mixtures.

The final ground powders are blended, milled, sifted and subdivided. Dust tends to escape from each operation. By the use of proper hooding of dust sources the dust is drawn into Sly Dust Collector. About 1.10 to 1.25 percent of each mixture is recovered and reused.

During the past ten years Merck has installed 21 Sly Dust Filters —a fine tribute from a fine company.

No matter what you make or process—if there's dust, you need Sly.

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NAMES . . .

with Merck & Co. **Loren C. Hurd** is now president and a director of the Metals Disintegrating Co., Inc.

Bryce Rhodes has been named development and production staff manager for International Minerals' phosphate chemicals div.

Robert R. Lichliter is the new superintendent of Virginia-Carolina Chemical's phosphoric acid and sodium tripolyphosphate plant at Fernald, Ohio.

Major General Louis W. Prentiss has been appointed Commanding General of the Engineer Research & Development Labs, US Army, Fort Belvoir, Va.

George Soyka has been selected for the newly created position of technical director of John W. Bolton & Sons, Inc., Lawrence, Mass.

R. G. Altizer has been appointed assistant to the president, Magnus Metal Corp.

Frank E. Large has been appointed manager of engineering and development for the National Carbide Co.

Stanley Hermann and **James R. Kaiser** are new members of Proctor & Gamble's products development and research and development staffs, respectively.

Edward L. Locke has been promoted to works manager of Pennsalt's Portland, Ore., plant.

Jesse Hobson, director of Stanford Research Institute since 1948, will resign March 31.

Paul A. Vogel is the new director of commercial research of the Shea Chemical Corp.

Alfred N. Rogers has been selected by Baldwin-Lima-Hamilton Corp. as chief engineer of its newly formed Nuclear Eng. department. Formerly, Mr. Rogers worked with the AEC as a scientific assistant.

OBITUARIES



S. D. Douglas

The senior scientist of Carbide & Carbon Chemicals' research department—Dr. S. D. Douglas—died on January 15, just a few days after his new appointment.

In 1944, Dr. Douglas received the nation's most distinguished award for achievement in the plastics industry — the John Wesley Hyatt gold medal. His contribution of seventeen years of intensive development in the field, made possible the increased production of vinyl resins so vital during the war as a stand-in for strategic materials.

Dr. Douglas joined Carbide thirty years ago. In 1944, he became assistant director of research. In his new capacity, he was to conduct the firm's basic research.

Edward D. Youmans, vice president in charge of research and product development of the Okonite Co., died of a heart attack at his home on December 18.

Frank E. Payne, chairman of the board and co-founder of Crane Packing Co., died November 20 at his home in Glencoe, Illinois.

Chester H. Jones, former western editor of CE's predecessor —Chemical & Metallurgical Engineering — passed away quite suddenly, January 7.

Harold S. Kendall, 62, asst. to the president of Dow Chemical since 1941, died at his home in Midland, Mich., January 8, after a long illness.

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Dings DYNAMIC



PERMA-PLATE MAGNETS

FOR EFFICIENT—LOW COST TRAMP IRON REMOVAL

DINGS—The world's largest exclusive builder of magnetic separation equipment—now brings to all industry an entirely new concept of efficient, low cost tramp iron removal . . . through the completely new line of non-electric Alnico Perma-Plate Magnets, incorporating the *DYNAMIC* principle of magnetic separation.

Designed and built to remove tramp iron from moving material carried in chutes, ducts, on conveyor belts and slides, these new powerful, guaranteed permanent Alnico V magnets are used to separate iron from grain, feed, chemicals, foodstuffs, plastics, fertilizers, minerals, textile fibers, liquids and wet and dry solids of many kinds. Perma-Plates are also needed wherever tramp iron or iron of abrasion can damage processing equipment, create fire hazards, or contaminate product purity.

Clip the coupon for full details.

The new Dings DYNAMIC Perma-Plates are plate type permanent non-electric Alnico magnets designed to attract moving iron. This proven design is the result of hundreds of extensive *dynamic* tests . . . *not* based on static tests.



As shown by illustrations (1) and (2), a *pull test* is a static test having negligible bearing on the magnet's ability to attract rapidly moving iron. It is not *dynamic.*

Illustration (3) shows a *lift test,* again a static test having negligible bearing on the magnet's ability to attract moving iron. It is not *dynamic.*



Illustration (4) shows a *chute test* . . . the only *true* test of a plate magnet's ability to attract rapidly moving iron. *This is the DYNAMIC principle of operation of the new Dings Perma-Plate Magnets.*

The new Dings Perma-Plates are available in 4 basic types, offering effective magnetic ranges from 2½" through 4". Each type is available in 35 standard sizes from 4" through 72" wide.

Complete details of these versatile DYNAMIC Magnets are given in the new Catalog 1205-D, just off the press. Mail coupon for your copy.



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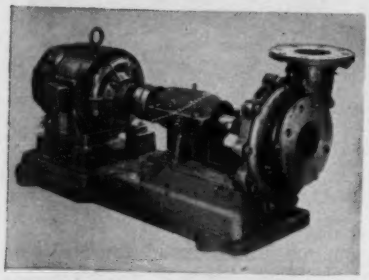
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- One piece impellers, secured to shaft by key and lock nut, or threaded, give long service.
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Enclosed impeller types for chemicals, oils, juices, clear liquids, acids, etc. Open impeller types for slurries, brewery mash, food mash, white water, paper stock up to 2% consistency, etc. Constructed of metals to meet *your* requirements—cast iron, nickel, stainless steel, monel, etc. Send your requirements to our skilled staff for suggestions. Ask for free copy of Bulletin 107.

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STOP THAT PULSATION!

Drop pipe-line maintenance and service costs sharply — improve flow control and operating efficiency of your equipment by eliminating vibration caused by line surges from compressors, pumps and blowers. In new layouts eliminate cost of special and extra heavy supports to secure piping from vibration.

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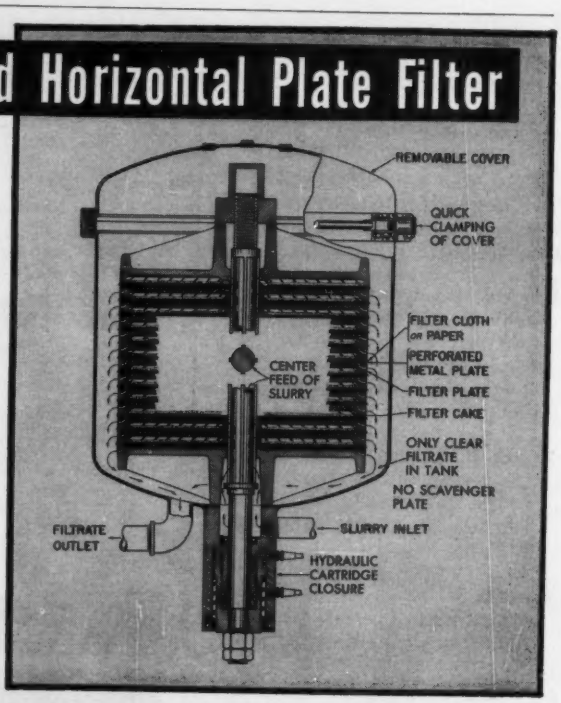
Sound Engineering 723 East Park Avenue, Libertyville, Illinois

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Enclosed Horizontal Plate Filter

Leakproof
Vaporproof
●
for Batch or Continuous Operation
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Cake stays in place even when run is interrupted
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Easy to clean

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Filter Presses · Filter Media · Diaphragm Pumps

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Sales Representatives In
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San Francisco–Montreal–Toronto

Letters Pro and Con

EDITED BY C. H. CHILTON

Pro: Engineers in Sales

Sir:

Dow Corning's accomplishments in the field of silicones are certainly deserving of the Chemical Engineering Achievement Award. Their selection was an excellent choice.

Creation of a market is a most difficult job. As your article points out (Dec. 1955, pp. 175-182), discovery in research and solution to pilot-plant and production problems in many cases leave an organization far short of its goal in a business enterprise. The many additional marketing, development and selling problems which remain must be solved before the enterprise is a success. I was pleased to see you focus editorial attention on the contribution technical people can make to the sales function.

Acquiring adequate numbers and quality of technical personnel is a major problem in every part of industry (and the academic field as well). In the industrial sales field this problem is particularly severe because of a somewhat general feeling that the work is not as challenging or important as research, or even production.

To the contrary, the technical and business problems in sales are certainly at least as complex, as difficult to define and solve as in any other part of a business. Steps taken to get across to technical people the fact that technical work in sales is essential, important and difficult to do well—and rewarding when done well—will strengthen our chemical industry and our society.

JOHN P. WILKINS
E. I. du Pont de Nemours & Co.
Wilmington, Del.

Pro: Vessel Design Charts

Sir:

In the article, "Help in Designing Pressure Vessels" (Feb. 1956, pp. 171-3), Mr. Schneider has prepared a very clear and concise presentation of a complicated subject. I am surprised that he was able to compress it into little more than a full page of three-column text.

The charts cover the practical range that was suggested in my discussion of the Watts and Lang paper. In fact, they present the prior work in a final form that is immediately useful to the pressure-vessel designer. The charts, therefore, will be very helpful to engineers and designers.

There are no pitfalls that I can see in Mr. Schneider's method. However, at the top of the middle column on p. 172 he states that the constants are based on steel construction. Actually, they are based on any material having a Poisson's ratio of 0.3, which for all practical purposes includes any ferrous or nonferrous material now permitted for pressure vessel construction. I think this is worth clarifying, because many designers are interested in pressure vessels made of stainless steel and aluminum, copper, nickel and their alloys. General applicability of the formula comes about because the modulus of elasticity, which varies among these materials, cancels out in the process of deriving the formula.

You have done a real service to designers by publishing this article.

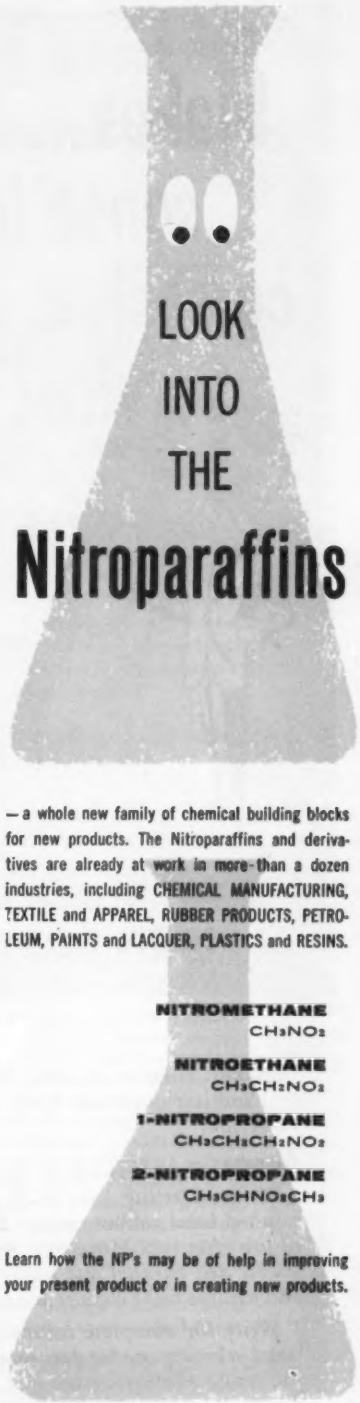
D. B. WESSTROM
E. I. du Pont de Nemours & Co.
Wilmington, Del.

▶ *Although Designer Wesstrom finds no difficulty with selection of design stress, Author Schneider clarifies this point of possible misunderstanding in the letter which follows. If you're looking for a challenging research problem, here it is.*—ED.

Needed: More Stress Research

Sir:

In *Problem II* (Feb. 1956, p. 173) a figure of 18,000 psi. is given for the maximum allowable design stress. When secondary stresses exist, such as those in an integral flat-head closure, a question usually arises regard-



—a whole new family of chemical building blocks for new products. The Nitroparaffins and derivatives are already at work in more than a dozen industries, including CHEMICAL MANUFACTURING, TEXTILE and APPAREL, RUBBER PRODUCTS, PETROLEUM, PAINTS and LACQUER, PLASTICS and RESINS.

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1-NITROPROPANE $CH_3CH_2CH_2NO_2$

2-NITROPROPANE $CH_3CHNO_2CH_3$

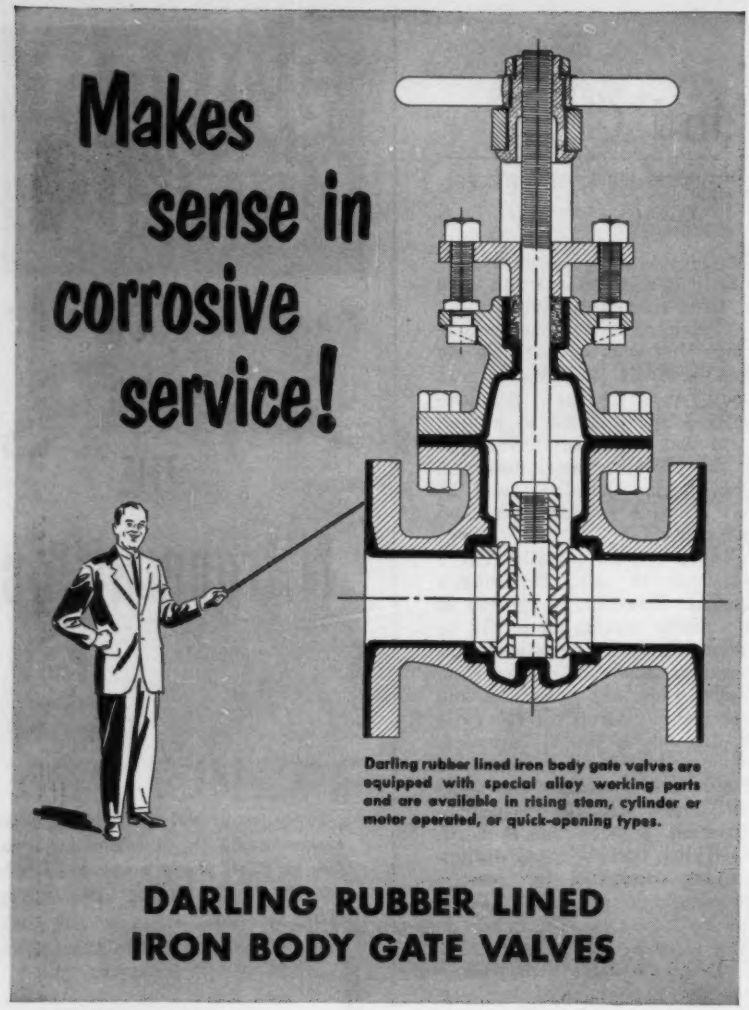
Learn how the NP's may be of help in improving your present product or in creating new products.

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Problem: How to get away from costly, special alloy gate valves in handling corrosive fluids and still have long, trouble-free valve life.

Answer: For pressures up to 150 pounds and temperatures to 180° use Darling iron body gate valves with the permanently bonded hard rubber lining. They're giving outstanding service in job after job. Moreover, they have the Darling *fully revolving double disc parallel seat feature* that multiplies disc and seat life and assures tight closure longer . . . much longer!

Write for complete information on these exceptional rubber lined valves . . . or for data on other Darling gate valves including the range of alloys, types and constructions for ordinary or special services.

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ing the selection of a design stress.

It was impracticable to cover the subject in detail in this short article since it is a subject in its own right.

When T/t is greater than 1.0, as was the case in my article, the designer is concerned with the axial stress in the shell at the junction. It is often permissible to let this stress exceed the allowable membrane design stress, since it is local in nature and disappears a short distance from the junction.

At the present time it is impossible to define to what extent this stress may exceed the membrane design stress, since this question must be answered on the basis of the results of research yet to be done.

This problem is related to establishing design stresses and in no way affects the usefulness of the design charts.

R. W. SCHNEIDER
Travelers Insurance Co.
Hartford, Conn.

Wait for Better Model?

Sir:

In my article, "Replacement Analysis by Capitalized Costs" (Aug. 1955, pp. 181-8), the advantage, expressed as a capitalized cost, in retaining the Existent for one year so as to obtain the technological advantage of a later model Replacement was given as

$$K = R\,(G_1 - mG_m) \qquad (14)$$

where R is the anticipated technological advancement expressed as a reduction in expense in dollars per year per year, and m is the life of the article.

The advantage, expressed as a capitalized cost, in waiting q years was given as

$$K = R\,F_1\,(G_1 - mG_m)\,/\,F_q \qquad (15)$$

Eq. (15) is based on a number of assumptions which could not be discussed in the article. Another interpretation leads to the following equation:

$$K = R\,F_1\,(qG_q - mG_m)\,/\,F_q \qquad (15A)$$

Eq. (15A) is probably more realistic and for the sake of completeness is given here.

Note that both Eqs. (15) and (15A) reduce to Eq. (14) for $q = 1$.

For values of q greater than 1,

Eq. (15) gives a higher value than Eq. (15A). For values of q up to $m/4$ both equations give about the same results. In practice Eqs. (15) and (15A) have only a very minor effect on the over-all calculation; moreover q is usually small compared to m, and over this range the equations agree somewhat.

Eq. (15A) is correct for any value of q from 1 to m inclusive.

It is inconceivable that q would ever be chosen greater than m, but if so, proceed as follows: For a value of q equal to, say, $(2m + 3)$, calculate K from Eq. (15A) on the basis of $q = 3$ and divide the result by $(1 + i)^{2m}$.

F. C. JELEN
Solvay Process Div.
Allied Chemical & Dye Corp.
Syracuse, N. Y.

Distillation Aftermath

Sir:

Ever since publication of my article on "Binary Distillation" (Sept. 1954, pp. 168-188), and partially as a result of this article, I have been submerged in consulting problems on column evaluation and design. Approximately 20 of the columns are either in construction or in operation.

Also, evaluation of Tellerette tower packing has now been accelerated. Some promising information has been obtained concerning an unexpectedly large flow capacity at low pressure drops.

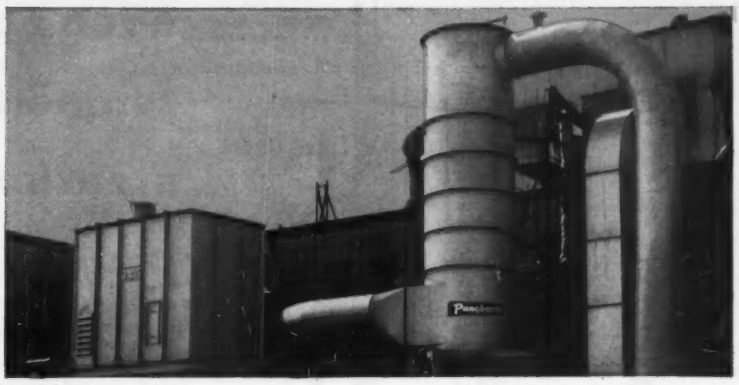
Furthermore, we've been statistically evaluating the comparative contributions of interstitial holdup and surface to mass transfer. Results are not complete but look good.

In addition we have just completed the installation of equipment for comparison of performance of five packings and two tray types in the same column and same system. Results should be interesting.

AARON J. TELLER
Fenn College
Cleveland, Ohio

► *Further proof, if it is needed, that publication of an outstanding article in CE brings well deserved recognition to its author. Prof. Teller's report is one of our best reprint sellers.*—ED.

For efficient control of process plant dusts



The Pangborn Centrifugal Wet Dust Collector was designed to handle dusts difficult to control with dry type collectors. Therefore, it is particularly suited to the process plant for all phases of experimentation or production. According to one user, "We are well pleased with the Pangborn Wet Collector. It does its job efficiently, economically and we've encountered no maintenance difficulties whatever."

Pangborn Centrifugal Wet Collector



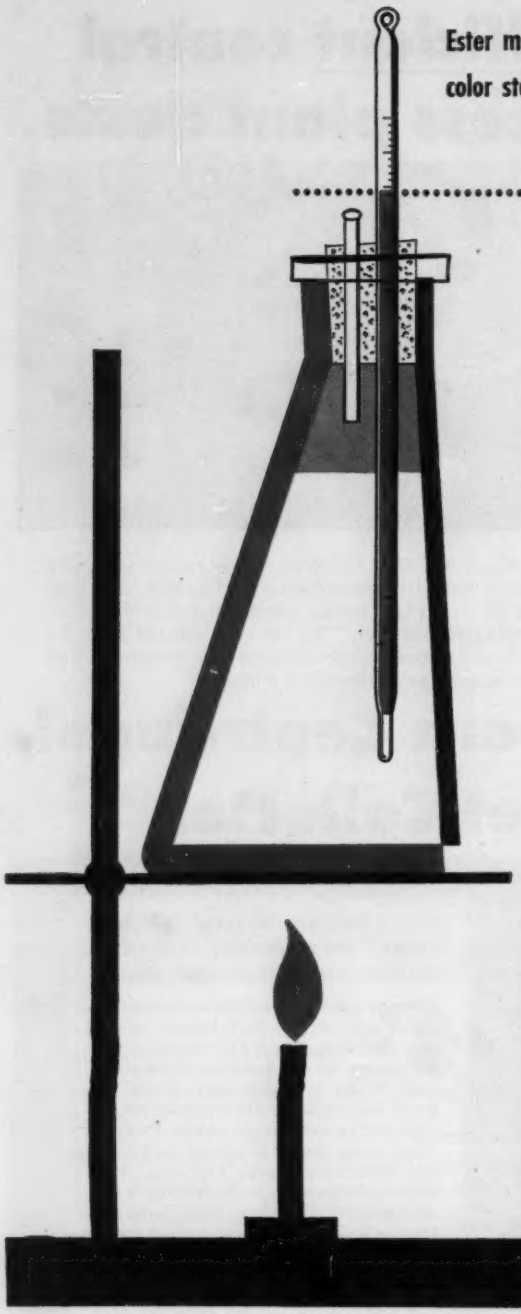
For effective control of hot, moist, inflammable, abrasive, corrosive and obnoxious dust

Effective interaction of air and water explains the efficient performance of this new Centrifugal Wet Dust Collector by Pangborn. Dust-laden air enters the bottom of the collector tangentially and heavy dust particles are immediately precipitated by centrifugal action. Patented vanes cause the air to ascend on a tortuous centrifugal path, exposing it to thorough cleansing by descending water, after which it discharges through the top. Unique Pangborn counter-current design results in greater efficiency of operation, reduced space for rated capacity, lower operation cost through reuse of water and capacity geared to individual needs.

Pangborn CONTROLS DUST



If *your* dust problem involves the control of dust difficult to handle with a dry collector, write for details on the new Pangborn Centrifugal Wet Collector! Send for Bulletin 919 to PANGBORN CORP., 2600 Pangborn Blvd., Hagerstown, Md.
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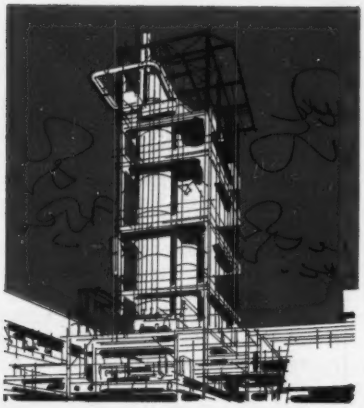
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18-58 70% Stearic
18-61 80% Stearic

OLEIC ACIDS
Neo-Fat 92-04 Low Titer White Oleic
94-04 Low Titer Red Oil
94-10 High Titer Red Oil

THIS MONTH'S

Technical Bookshelf

EDITED BY R. K. GITLIN

Chemical Equilibrium

THE PRINCIPLES OF CHEMICAL EQUILIBRIUM. By K. G. Denbigh. Cambridge University Press, England. 491 pages. $7.50.

Reviewed by H. Y. Krinsky

"My aim has been to write a book on the general theory of chemical equilibrium, including its statistical development, and displaying its numerous practical applications, in the laboratory and industry, by means of problems." So writes Dr. Denbigh in the preface to this new book.

That the author has been successful in his aims will be readily apparent to the reader. Denbigh has written a text expressly for graduate students in chemical engineering and chemistry which is concise, logically developed, readable and, if the term can be applied to thermodynamics, entertaining.

The book is divided into three parts dealing with the laws, equilibrium and statistical considerations — in that order. Featuring the section on laws of thermodynamics is an introduction to the informational or amount-of-knowledge concept of entropy. The section dealing with equilibrium introduces the thermodynamics of gasses, the equilibrium constant and equilibrium reactions of gases. The rest of this section is involved with a discussion of phase rule and the thermodynamics of solutions.

The last section of the book introduces the statistical concept of thermodynamics and discussions of the third law, kinetics and the work of Glasstone, Laidler and Eyring concerning transition states.

Perhaps the most unique features of this book are its clarity and problems. Denbigh has not resorted to the usual "It is obvious that . . ." or "As is easily seen . . ." He has derived most of his equations completely and has included, in ample footnotes, derivations and clarifications which permit the reader to follow the text logically.

The problems at the end of each chapter include some exercises from the Cambridge University chemical engineering qualifying and tripos (honor) exams. These problems are interesting—useful both as comparisons and as possible sources of new ideas in problem formulation.

Denbigh has written a text which will be a welcome addition to the literature of thermodynamics. It is felt that this book should prove important to students and teachers of this science.

Mass Transfer

MASS-TRANSFER OPERATIONS. By R. E. Treybal. McGraw-Hill Book Co., New York. 666 pages. $9.50.

The mainline of the Central Railroad of New Jersey runs through the chemical meadows of that highly industrialized state. Although the road performs many more significant services, one of its tasks is to haul young chemical engineers from the chemical plants and oil refineries along its trackage to the universities of New York City, where they pursue higher education on a part-time evening basis.

And so, one overcast winter evening, the Perth Amboy local was making its usual collection. A stop at Barber brought in two from the California Oil Co. refinery. At Tremley, General Aniline & Film, Du Pont and American Cyanamid made their contributions. Chem. E.'s from Esso Research and Reichhold Chemical hopped on at the Bayway station.

Frank leaned over to ask, "What you got tonight?"

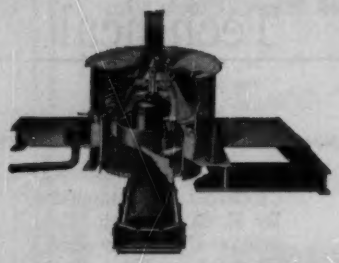
"I've got mass transfer at the Heights."

"Who gives that, Treybal?"

"Yes."

"Any good?"

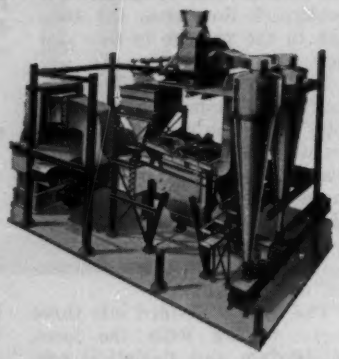
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"Best they have in the Chem. E. department."

Somewhere between Bayonne and Jersey City the conversation continued.

"Looks like fog on the river. The ferries will probably be all tied up."

"Damn. This is the only night of the week that I can't afford to be late to class. Walk in five minutes late to Treybal's class and you've missed three pages of notes."

"Well, can't you make it up with the textbook?"

"No. There isn't any book that can give you what he gives you in his lecture notes. I wish he'd finally get around to publishing that book he's been working on. It would be a big help."

Well, now it's here—as an addition to the Chemical Engineering Series. And it's an extremely valuable and practical addition. Bob Treybal is a master craftsman. Over the past 15 years he has developed his technique of getting the most out of a semester to a fine edge.

First he crams his students full of engineering science. Just when they think they'll burst, he switches to the "how to" approach—how to design towers, columns, trays, bubble caps, extractors, absorbers, etc. And his students stagger out into industry ready to tackle the practical problems of chemical engineering equipment design and operation.

But, as you will see in this book and in his earlier volume on liquid extraction, Dr. Treybal is one of our finest chemical engineering scientists that we have today. He'll use the rule-of-thumb approach when it's called for, but he insists on an appropriate respect for sound engineering theory backed up by experimental evidence.

This book is intended for use on the undergraduate level. However, it will take very careful selection by the instructor to keep the discussion within the bounds of an undergraduate year. Professor Treybal himself works at break-neck speed to convey all the meat to his graduate students and keep within the limits of a single academic year.

You will find problems at the

end of each chapter, but no answers. This difficulty can be overcome easily.

Assign the problems to a class of students for homework. Someone will get to an answer by the time the class meets again. Enough repetitions of this procedure will develop the correct answers after a period of several academic years.

We are quite pleased with Treybal's division of the diffusional unit operations into such groupings as gas-liquid separations, solid-fluid operations, etc. For some time now we have felt that there are too many operations that don't deserve the title of unit operation and that a more useful classification scheme will eventually evolve. Treybal is definitely on the right track.

For you fellows out in industry, this book will be most helpful in refreshing your methods for the design of commercial equipment. And you'll certainly want to look at some of the newer developments in engineering theory.

This is a good book. Recommended for all.—RFF.

More on Safety

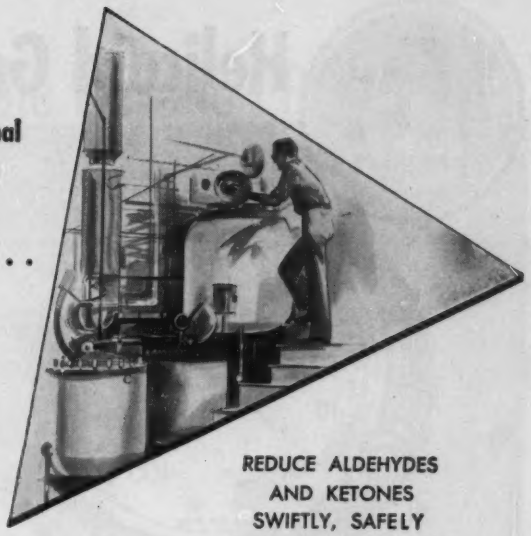
SAFETY IN INDUSTRY. By D. I. Macfarlane. Philosophical Library, New York. 71 pages. $6.

The value of this slim volume to industrial executives and plant personnel is inversely proportional to the number of pages. For every one of the 71 pages is packed with clear, concise information on ways in which plants and premises can be made safer.

Each of the eight chapters covers the do's and dont's of safety as applied to specific operations. For example, the chapter on dust and fume control discusses the necessity of high standards of general ventilation as well as the well-designed apparatus to remove atmospheric contaminants, continuing research work being done on scientific ventilation, most economical methods of dust and fume collection with large numbers of machines.

The section on rotating machinery lists the ten major

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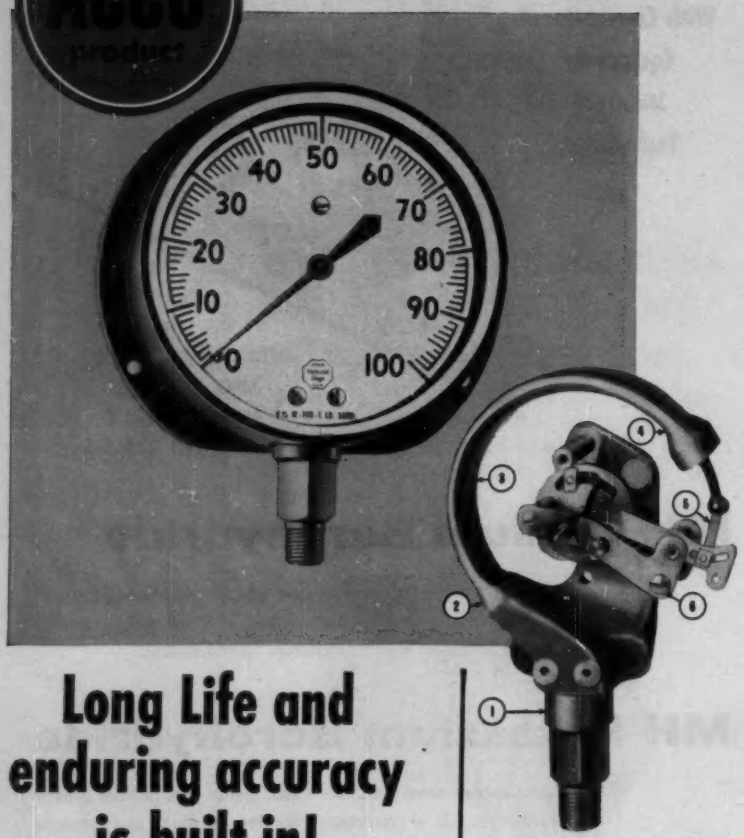
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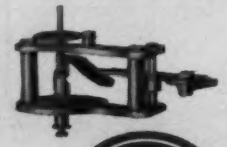
Bourdon tube* (3) is alloy steel, stainless steel or K Monel.

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causes of serious accidents in such machines and how these can be eliminated by appropriate use of guards.

Similarly, chapters on press guards, dermatitis, eyes, iónizing radiations, protective clothing, lighting and flooring cover what can and should be done to protect the worker from injury.

Over 70 photographs (and diagrams) are coordinated with the text to bring home the safety lesson. And in several instances (e.g., illustrations of various types of dermatitis and eye injuries) the photos themselves are more effective than the accompanying text. For what better way of illustrating the rules of safety than pointing to a this-could-happen-to-you picture.—RKG

Information Media

INFORMATION PROCESSING EQUIPMENT. Edited by M. P. Doss. Reinhold Publishing Corp., New York. 270 pages. $8.75.

Whether you're in the throes of writing a letter, memo or report for wide distribution or surrounded by a maze of technical information that must be stored or filed, this book is for you.

Within its covers are described the latest advances in everything from automatic typewriters to xerography (dry photographic copying). And although much of the information may be old hat, some of it isn't. Did you know, for example, that the Potter flying typewriter types 25,000 words per minute (page 7) or that the ERA 1103 general-purpose computer can perform 1,000-2,000 multiplications or division a second and 10,000-15,000 additions or subtractions a second (page 244)?

Whatever your problem in reducing that mountain of paper work, you're sure to find the answer—or a clue to it—in this book. Each chapter has a list of equipment manufacturers mentioned in the text. So if you can't discover what you're looking for, you can go directly to the industrial source.

Scientific personnel should find this a valuable reference to keep on their bookshelves.—RKG

Briefly Noted

ASTM STANDARDS ON PLASTICS (October, 1955). 790 *pages.* $5.75. *American Society for Testing Materials,* 1916 *Race St., Philadelphia, Pa.* Compilation of ASTM standards and tentative specifications, methods of analysis, methods of physical testing, recommended practices and definitions of terms pertaining to plastics. Of the 143 specs and tests presented, 4 are entirely new and 41 have been either revised, reaffirmed or advanced from tentative status to standard.

BOUNDARY LAYER RADIOACTIVE TRACER TECHNIQUE. PART 1, INSTRUMENTATION. 107 *pages.* $2.75. *OTS, U. S. Dept. of Commerce, Washington 25, D. C.* Describes application of tracer technique for measurement of velocity profiles in flowing fluids to measurement of liquids in laminar flow in round tubes.

CRANE HANDBOOK. 176 *pages.* $10. *Whiting Corp., 157th and Lathrop, Harvey, Ill.* 17 sections covering practical data on electric traveling cranes, including terminology and classification, operating speeds, overhead clearances, safety features, operation and maintenance instruction, elements of design, auxiliary equipment, etc.

A.G.A. FLOW CONSTANTS. $10. *Foxboro Co., Foxboro, Mass.* Compiled as a supplement to "Principles and Practice of Flow Meter Engineering." Contains 77,811 separate flow calculations evaluated to six figures, 111 pages of tables. Includes values of S for an infinite Reynolds number, values of E and values of K derived from equations developed by Buckingham and used by A.G.A. and A.S.M.E. Figures are presented in d/D steps of 0.001 to 0.800 for each of 37 line sizes from 1.535 in. I.D. to 29.95 in. I.D.

REACTIONS OF CARBON WITH CARBON DIOXIDE AND WITH STEAM. 76 *pages.* $7.50. *By C. G. von Fredersdorff. Institute of Gas Technology, Chicago 16, Ill.* Discusses, in detail, the three-part problem of (1) obtaining and interpreting typical reaction rate data for high-temperature gasification of a specific fuel (pitch coke) with carbon dioxide and steam at atmospheric and super-atmospheric pressures, as a contribution to the over-all carbon-oxygen-steam reaction, (2)

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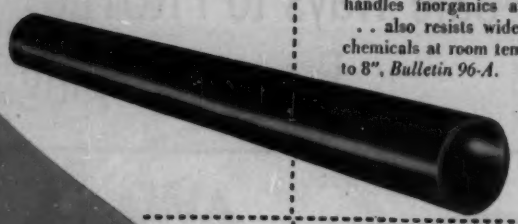
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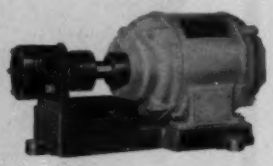


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analysis of these systems to develop relationships which may have general applicability for estimation of chemical and physical factors and the distribution of products of gasification processes, (3) application of these relationships in interpreting product distributions and reaction rates in a cyclic gasification system.

WOOD HANDBOOK. 528 *pages.* $2. *By Forest Products Laboratory of the Forest Service, U. S. Dept. of Agriculture. Supt. of Documents, Washington* 25, *D. C.* Up-to-date information on wood as a material of construction with data for its use in design and specification. Among subjects covered are structure and physical properties of wood, stress grades and working stresses, bent wood members, control of wood's moisture content and shrinkage, fire resistance of wood construction, wood preservation, etc.

USE AND CONSERVATION OF WATER RESOURCES IN EASTERN STATES. 7 *pages. By R. D. Hoak. Mellon Institute,* 4400 *Fifth Ave., Pittsburgh* 13, *Pa.* Reprint of paper presented in May, 1955, in Pittsburgh, covering water conservation value, discharge water, pollution determination and control, conservation measures, sea water demineralization, induced rainfall, river associations.

PITFALLS IN USING MAXIMUM CONCENTRATIONS IN AIR POLLUTION. 5 *pages. By H. H. Schrenk. Mellon Institute,* 4400 *Fifth Ave., Pittsburgh* 13, *Pa.* Originally presented at the April, 1955, meeting of the American Industrial Hygiene Association in Buffalo, N. Y., this paper covers various air pollution aspects including: information and criteria used in establishing limits, application of limit values, effect of air pollutants on health, environmental aspects of air pollution, industrial and community exposures.

KINETIC THEORY OF LIQUIDS. 488 *pages.* $3.95 (*clothbound*), $1.95 (*paperbound*). *By J. Frenkel. Dover Publications, Inc.,* 920 *Broadway, New York* 10, *N. Y.* Six of the eight chapters in this book deal with the liquid state—properties of liquids and mechanism of fusion, heat motion in liquids and their mechanical properties, orientation and rotational motion of molecules in liquid bodies, surface and allied phenomena, kinetics of phase transitions, properties of solutions and high polymeric sub-

stances. The first two chapters—real crysals at elevated temperatures, perturbation of alternation and orientation order in mixed and molecular crystals—consider the solid state from the point of view of amendments which must be introduced in the classical theory of ideal crystal lattices to bridge the gap between solid and liquid states.

DETERMINATION OF SHEAR STABILITY OF NON-NEWTONIAN LIQUIDS. 12 *pages.* 75¢. *By N. D. Lawson. American Society for Testing Materials,* 1916 *Race St., Philadelphia, Pa.* Describes such test methods as sonic vibrators, sharp-edged orifices, flow through a diesel fuel injector, pressure release valve for measuring shear stability of non-Newtonian liquids. Of value to those concerned with development or use of polymer liquids and mechanical devices in which those liquids are used.

TABLE OF THE DESCENDING EXPONENTIAL. 76 *pages.* 50¢. *By National Bureau of Standards. Supt. of Documents, Washington* 25, *D. C.* Tabulates the descending or negative exponential, e^{-x}, from x values of 2.5 to 10, at intervals of 0.001 to 20 decimal places. Table provides greater accuracy than heretofore available in this range, thus facilitates interpolation.

TABLE OF HYPERBOLIC SINES AND COSINES. 81 *pages.* 55¢. *By National Bureau of Standards. Supt. of Documents, Washington* 25, *D. C.* Tabulates sinh x and cosh x for values of x from 2 to 10, at intervals of 0.001. For values of x from 2.000—2.943, sinh and cosh are given to eight decimal places; for 2.944—5.249, to seven places; for 5.270—7.600, to six places; for 7.601—9.903, to five places; for 9.904—10,000, to four places.

More New Books

DESIGN OF PIPING SYSTEMS. M. W. Kellogg Co. Wiley. $15.

DIE KUPPELPRODUKTION—BETRIEBS UND MARKTPROBLEME. By P. Riebel. Westdeutscher Verlag. DM21.

DISTILLATION IN PRACTICE. Edited by C. H. Nielsen. Reinhold. $3.

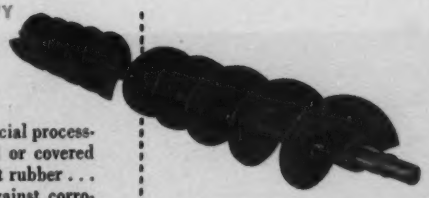
CHEMICAL PILOT PLANT PRACTICE. By D. G. Jordan. Interscience. $3.50.

MODERN PHYSICS—A TEXTBOOK FOR ENGINEERS. By R. L. Sproull. Wiley. $7.75.

TEMPERATURE—ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY. Vol. 2. Edited by H. C. Wolfe. Reinhold. $12.

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"Yes, they do. These Type C louvers make it easy to get into the tower. Now, take a look at the way those strippers have been placed above the louver openings and the arrangement of the posts and ties."

"Is that important?"

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"Ice is a serious problem, isn't it?"

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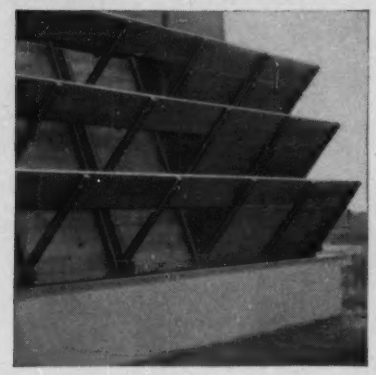
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For coldest climates– Pritchard Type WX Louvers



These sturdy Type WX louvers instantly solve the problem of ice formation even in coldest climates. The wide louvers are supported in a frame set out from the tower. Splashing water can't reach the louvers and form ice.

Each louver is individually hinged. It can be opened or closed to control air flow into the tower. Thus, water temperature and ice formation are controlled, too. You can shut Type WX louvers off on the windward side and leave the louvers on the other side open. And, the entire operation can be accomplished right on the ground. It's safer, more convenient.

Pritchard Louvers—Type C for temperate climates, Type WX for coldest climates—are just one more reason for choosing Pritchard Cooling Towers!

Pritchard Industrial Cooling Towers meet or exceed new CTI standards.

GET THE WHOLE STORY!



Send for "Answers to the 15 Questions About Pritchard Induced Draft Cooling Towers." It's fascinating, profitable reading. Write today on your company letterhead for your complimentary copy. No obligation, of course.

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THIS MONTH'S

Firms in the News

EDITED BY F. ARNE

New Companies

Balfor Industries, Inc., New York, has ben formed to specialize in the manufacture of Teflon products including such basic shapes as rod, tube, sheet and slab.

Clark Equipment International, C. A., has been formed in Venezuela by Clark Equipment Co.—manufacturer of materials handling equipment—to consolidate export functions of the firm's operating divisions throughout the world.

Dow Chemical Co. and Kilachand, Devchand and Co. Ltd. of India have formed a company in Bombay to manufacture Styron, Dow's polystyrene plastic, for Indian molders.

Fenco Corp., San Francisco, has been formed to manufacture household cleaning preparations.

Rias, Inc., a subsidiary of Martin Co. of Baltimore, Md., has been formed to apply business management and an industrial environment to basic research and to allow a selected staff of scientists to create and develop their own theoretical and experimental studies.

New Representatives

Morris Machine Works of Baldwinsville, N. Y., manufacturers of heavy duty slurry pumps, has named Cross Pump & Equipment Co. of Charleston, W. Va., as its sales representative in southern West Virginia, eastern Kentucky, and western Virginia.

California Spray Chemical Corp., San Francisco, has authorized Agricultural Ammonia Service Inc. as its sole distributor for ortho ammonia for agricultural use in the San Joaquin Valley and Los Angeles, Ventura and Santa Barabara counties.

Darlington Chemicals, Inc., Philadelphia suppliers of magnesium oxide, magnesium carbonate and magnesium hydroxide, has appointed B. E. Dougherty Co., with offices in both Los Angeles and San Francisco, as its western representative.

Foremost Food & Chemical Co., El Dorado Div., Oakland, Calif., has appointed M. B. Sweet Co., Chicago, as sales agent for its products in northern Illinois and Indiana and eastern Wisconsin.

American Cyanamid Co. has appointed the following manufacturers and sales agents for its Accopak paper pallets, a kraft paper sling fitted with spiral-wound paper tubes which support a load up to 4,000 lb.: Mead Board Sales, Inc., Lynchburg, Va.; Sonoco Products Co., Hartsville, S. C.

Foster D. Snell, Inc., New York, has appointed Biochemical Procedures, Beverly Hills, Calif., as its West Coast laboratory.

Simpson Electric Co., Chicago, has named E. A. Dickinson & Associates, Milwaukee, as its sales representative in most of Wisconsin.

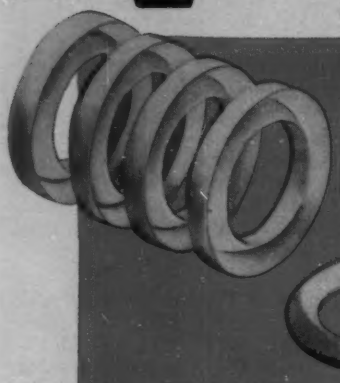
New Locations

T. J. Cope, Inc. and its Instrof Corp. division, manufacturers of expanded metal trough to support power cables in utilities and industrial plants, have moved from Philadelphia to Collegeville, Pa.

Palmer-Bee Co. has moved its general offices from Detroit to Bloomfield Hills, Mich.

Allied Chemical & Dye Corp. will move the New York sales

V-PACKING for every process need



TEFLON . . .
CHEMISEAL PACKING

Chemiseal V-Rings are all TEFLON,* all low-friction, all-chemical resistant. Distinctive tapered V design offers greater flexibility and resiliency. Provides necessary seal at low gland pressure, reducing torque required to operate valves—imposes less load on reciprocating pump pistons. Outlasts other packings in chemical service, many times over.

*du Pont Trademark

Write for U. S. Gasket Catalog TP-1255 on Engineered Teflon Packings.



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GENERAL PURPOSE PACKING

The "Pressure-Sealing" V-Ring packing that expands toward rod and stuffing box wall on pressure stroke to automatically form the seal — and relaxes when pressure is released to allow free movement with minimum friction.

For all reciprocating rods and valve stems handling water, oil, solvents, steam, air and gas.

Write for Belmont Catalog 4-R-10 on Self-Sealing V-Ring Packings.



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Camden 1, New Jersey

The Belmont Packing & Rubber Co.
Butler & Sepviva Sts., Phila. 37, Pa.

U.S. GASKET · BELMONT PACKING

FIRMS . . .

offices of three of its divisions —Barrett, General Chemical, Solvay Process—to 261 Madison Ave. in May.

New Names

Synco Resins, Inc., the new name for Snyder Chemical Corp., Bethel, Conn., has been based on the trademark for the company's phenolic resins.

Pyrene—C-O-Two Corp. is the new company name resulting from the merger of the former Pyrene Mfg. Co. and C-O-Two Corp., both of Newark, N. J.

New Lines

Baldwin-Hill Co. can now make mineral wool felts having greater densities (from 2 to 15 lb. per cu. ft.) than previously because of new manufacturing facilities at Huntington, Ind.

Cook Paint & Varnish Co., Kansas City, Mo., has started to make Synthetasine 200, a plastic protective lining material for the inside of steel shipping containers, as a licensee of Synthetasine Protective Coatings, Inc.

Chas. Pfizer & Co., Brooklyn, N. Y., has concluded a patent licensing agreement with Schering Corp. covering the manufacture and sale of prednisone and prednisolone which were discovered in the latter's laboratories.

Koppers Co. has arranged to take over the marketing of textile dyes which have been made and sold by Pittsburgh Coke & Chemical Co. PCC retains its manufacturing facilities.

Dings Magnetic Separator Co., Milwaukee, has acquired facilities to make brick presses through the purchase of Chisholm, Boyd and White Co., Chicago.

United States Steel Corp.'s Columbia-Geneva Div. has started to market a new polyvinyl chloride plastic pipe

NOW! *The handling of liquefied petroleum gases, refrigerants and other light non-viscous liquids* **is a CINCH!**



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APCO *Process* PUMPS

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SPECIAL METALS

APCO'S are obtainable in any machineable alloy. Small amounts required. Result: ECONOMY.

New and difficult applications in modern industry pose a challenge to pump designers. Aurora engineers have met this challenge completely with the APCO TYPE Z4 Process Pumps — which combine the ideal turbine-type features, special metals where required, single mechanical seal and other latest design features for SURE RESULTS. We invite your inquiry.

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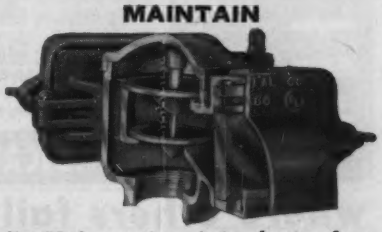
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FULLY FIRE PROTECTIVE
SIMPLE and EASY to MAINTAIN



Simplified, one-piece design locates flame arrester outside pressure-tight housing where it is easily accessible.

Vertical position of arrester permits condensate to drain off freely—prevents frequent "clog-ups" and prolongs operating time.

Modern "swing-bolts" permit quick removal of vent covers for visual inspection or removal of valves or arresters for cleaning.

Interchangeable arresters permit a spare to be inserted quickly and easily to safeguard tank while servicing original arrester.

Sturdy arrester plates resist distortion during cleaning and are self-positioning to assure correct air-space-gauging and safe reassembly to original Factory Inspection Standards.

Precision fabricated valves are processed to assure tight seatings, and are available as specified on order for other than normal pressure settings. Stream-lined design assures maximum air-flow capacities and self-drainage of condensate.



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For speed *and* accuracy in pressure measurements, investigate CEC's 37-103 Electromanometer. It equals manometer-tube accuracy (0.05% of full scale) . . . eliminates interpolation errors by reading out in *direct* numerical form. For complete details on this rugged industrial tool, send today for Bulletin CEC 1547-X13.

CHECK THESE FEATURES . . .

- fast response (4 sec. full-scale)
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- special, high-speed system with extra-high resolution. Response time of 0.1 sec. full-scale.

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AUTO-LITE

for EYE LEVEL READING



Auto-Lite Temperature Indicators are ideal for use in processing and storage rooms, and for installation on equipment where temperature indication is desirable.

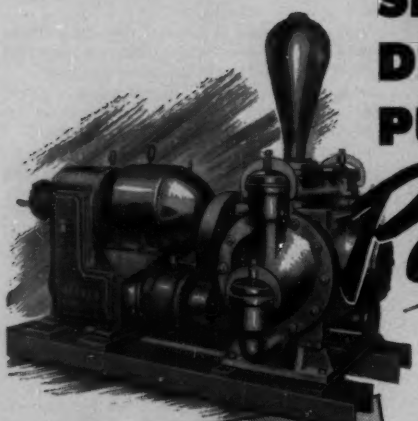
Model F-1 (illustrated) is available with maximum visibility dial; choice of temperature ranges from minus 60°F to plus 750°F; flexible tubing for remote reading or rigid stem for direct mounting. Adjustable electrical alarm contacts slightly higher. Priced from $22. Send for new catalog describing Auto-Lite Temperature Indicators and Recorders.

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TEMPERATURE INDICATORS AND RECORDERS

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SHRIVER DIAPHRAGM PUMPS Pay Off!



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It pays to use this positive action, large volume, efficient pump on materials that clog and destroy conventional pumps. No packings, no leakage; easy to clean and maintain; low operating cost. Built of any material; pressures to 100 p.s.i. Rated capacity—1 to 90 g.p.m.

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FIRMS . . .

product which is adaptable to many uses in the chemical, food processing, oil, gas and other industrial fields. Made by the company's National Tube Div., it is a lightweight material, rigid, unplasticized, highly resistant to chemical action and weather.

Republic Flow Meters Co., Chicago, has acquired a line of steam specialties through its purchase of the power plant equipment division of the Swartwout Co.

New Facilities

Esso Research Laboratories have announced a $1.5-million expansion of its Baton Rouge, La., laboratories including the addition of advanced X-ray and high speed computing facilities. Completion is set for early 1957.

Truesdail Laboratories Inc., Los Angeles, has established the first independent chemical laboratory in the territory of Hawaii.

International Salt Co., Scranton, Pa., has opened a new laboratory in New York, N. Y., for research and development on salt and related fields.

Mallinckrodt Chemical Works, St. Louis, Mo., has signed a contract for operation of all the Atomic Energy Commission's feed materials facilities in the St. Louis area.

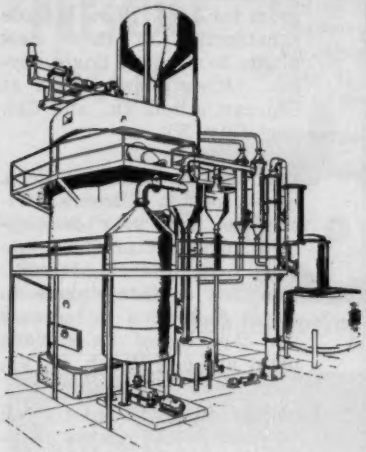
B. F. Goodrich Canada, Ltd., is building a new $3.5 million chemical plant, to make such products as Geon polyvinyl materials, in Thorold Township near Niagara Falls. Completion is set for early 1957.

Tennessee Products & Chemical Corp. is building a new $2.5 million electric furnace plant at Rockwood, Tenn., for production of ferro-alloys.

J. T. Baker Chemical Co. has completed additional unit process facilities at Phillipsburg, N. J., for manufactur-

FRENCH

FIFTY YEARS EXPERIENCE NOW AVAILABLE FOR THE EXTRACTION OF SOLIDS



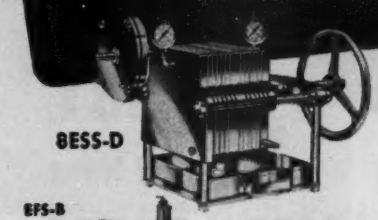
French has a record of extraction economy and efficiency in the oil milling industry extending over 50 years. French has more than twice as many full size extraction plants as any other equipment manufacturer in this country. These French plants process almost as much tonnage as all the others combined. French has achieved this leadership because FOMMCO plants give maximum efficiency and dependability—with minimum maintenance.

This experience in the profitable handling of extraction problems is now available to the chemical industry. Write today for suggestions on the most profitable method of handling extraction of any solid.

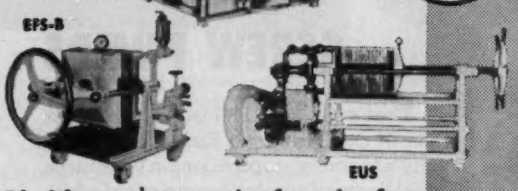
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Ideal for products ranging from ultra fine pyrogen solutions to coarse prefiltered bulk chemicals.

Send for Catalog illustrating the complete line of corrosion resistant filtration equipment.

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COMPLETE LINE OF *Liquid Handling Equipment*

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PUT IT RIGHT WHERE YOU WANT IT AND MAKE IT STICK!

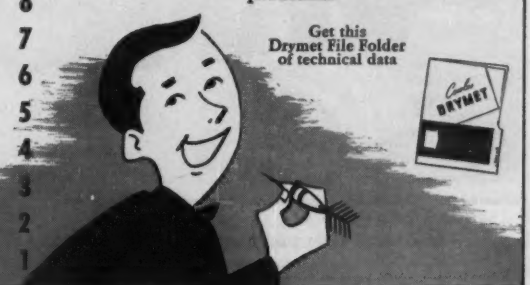


How strong a cleaner do you need? Mild —Medium—Heavy Duty? You can peg the pH exactly where you want it with

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ANHYDROUS SODIUM METASILICATE

Cowles Drymet blends easily with caustic soda, carbonates, phosphates, soaps, synthetics. Drymet gives you better detergency—more thorough soil dispersion—more complete emulsifying.

Let Drymet help on your formulating problems.

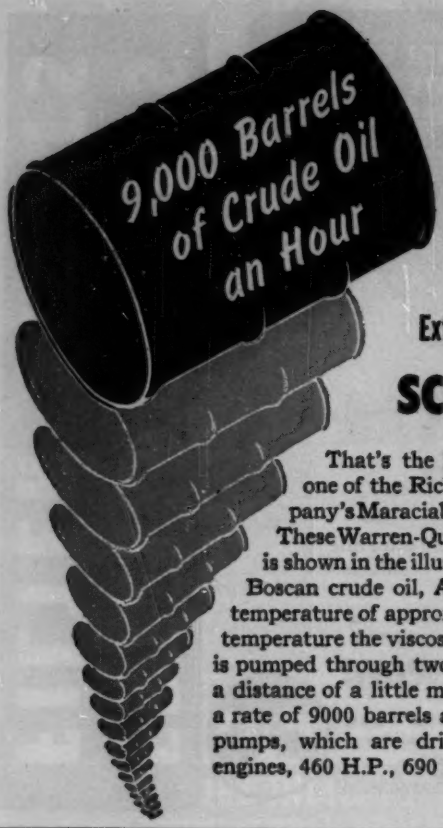


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That's the hourly loading record at one of the Richmond Exploration Company's Maraciabo operations in Venezuela. These Warren-Quimby Pumps, one of which is shown in the illustration, are used to pump Boscan crude oil, A.P.I. Gravity 10.5°, at a temperature of approximately 160°F., at which temperature the viscosity is 6000 S. S. U. The oil is pumped through two 18" submarine pipelines a distance of a little more than one mile and at a rate of 9000 barrels an hour, using three such pumps, which are driven by Nordberg diesel engines, 460 H.P., 690 R.P.M.

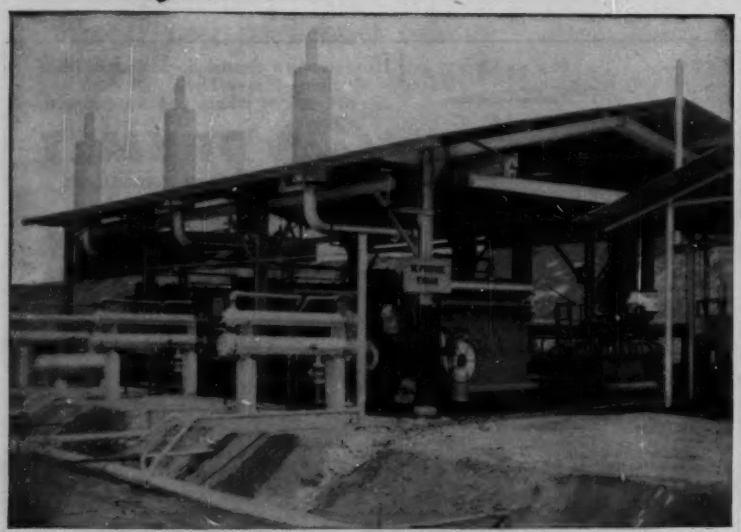


Illustration: Courtesy, Standard Oil Company of California

Whatever your pumping problem . . .
it will pay you to specify:

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PQ-7

WARREN PUMPS

WARREN STEAM PUMP COMPANY, INC.

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FIRMS . . .

ing purified and reagent chemicals in tonnage quantities.

Sohio Chemical Co. has begun first shipments of products from its new $17 million petrochemical plant at Lima, Ohio.

Atlantic Refining Co. has acquired the Houston Oil Co. of Texas.

Air Reduction Sales Co. plans a $16 million expansion program for 1956. Plans include construction of three new plants to produce liquid oxygen, nitrogen and argon at Chicago, Alton, Ill., and Calvert City, Ky.

Union Carbide & Carbon Corp. has formed a silicones division to take over development, manufacture and sale of silicone products. In addition, the company plans to spend $1 million to increase the capacity of its silicone plant at Long Reach, W. Va.

Rayonier, Inc., will build a tall oil plant at its chemical cellulose operation at Jesup, Ga. Much of the crude tall oil output will go to the Hercules Powder Co. plant at Savannah for further processing.

American Machine & Foundry Co. has established a commercial development division to handle new process developments primarily in the chemical field.

W. M. Barnes Co., Los Angeles, has placed the $1 million wax refinery of the bankrupt Sure-Seal Corp. at North Salt Lake City into operation.

Citi[illegible] Service Co. has opened a new product research center in Cranbury, N. J.

Reynolds Metals Co. will build an aluminum reduction plant at Listerhill, Ala., which will add 200 million lb. to its annual capacity of raw aluminum. According to a contract just signed with Ford Motor Co., aluminum in the molten



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● Whether you want conventional high-pressure units or something *special*—send us your inquiries. COLE can build you the kind of high-pressure tanks or vessels you require—any size, any shape, any metal. Our experience of a century (we were established in 1854) in the design and fabrication of metal tanks may be of help to you.

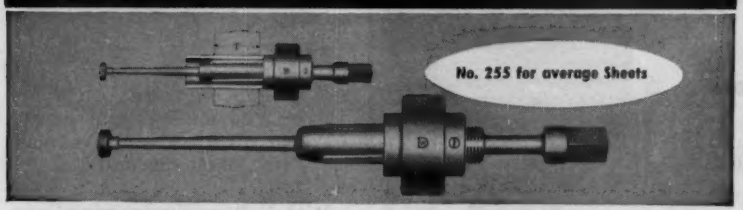
Send us your inquiries for tanks of all kinds. Write for Catalog—*Tank Talk.*

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IDEAL

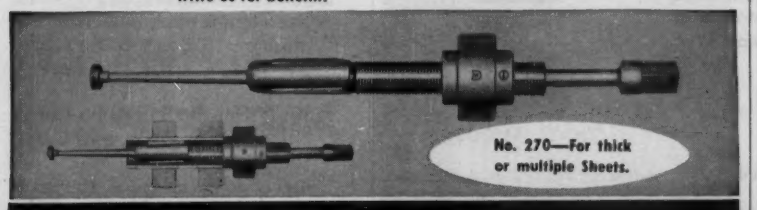
WIEDEKE Precision-Built Tube Expanders



Ball Bearing Adjustable Thrust Collar Tube Expanders are made for Tubes ¼" diameter and larger.
Recommended for use with any Controlled Rolling Motor for uniform expansion of Tubes.

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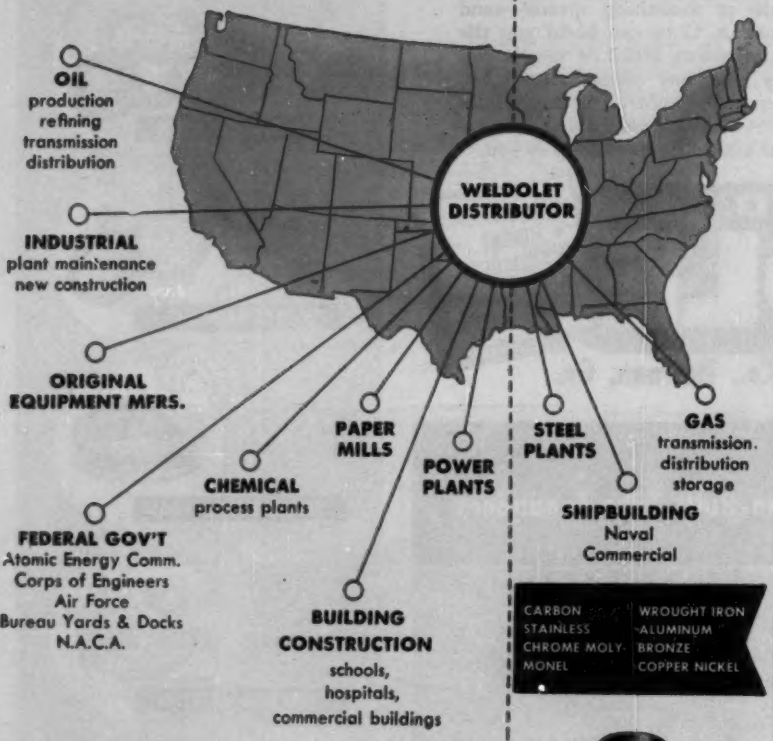
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FIRMS . . .

form from the new plant will be delivered to a Ford foundry to be built adjacent. In the next 10 yr., Reynold will deliver to Ford an amount in excess of 640 million lb.

National Starch Products Inc. has started construction of additional facilities which will double the capacity of its new polyvinyl acetate polymer plant in Meredosia, Ill.

Columbia-Southern Chemical Corp. plans a $1 million research unit at its Barberton, Ohio, plant for completion early in 1957.

Beckman Instruments Inc.'s Spinco Div., Belmont, Calif., has broken ground for a $500,000 research and development center in Stanford Industrial Park for work on medical instruments.

Alco Products, Inc. has just about completed a $230,000 nuclear laboratory at its main plant in Schenectady, N. Y.

Lummus Co., New York, has established an engineering development center in Newark, N. J.

Calaveras Cement Co., San Francisco, plans completion of a $4 million plant expansion of its San Andreas, Calif., plant this fall.

High Voltage Engineering Corp. is building the world's largest radiation machine test facility at Cambridge, Mass. Cost: $2 million.

Maumee Chemical Co., Toledo, has completed a new $100,000 plant section to replace facilities lost in a fire last year.

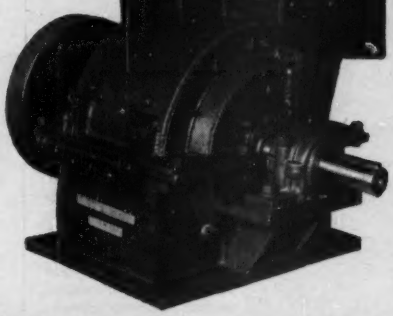
Mallory-Sharon Titanium Corp., Niles, Ohio, has purchased the Niles rolling mill, formerly a division of the parent company, Sharon Steel Corp.

Koppers Co. has announced that it will spend $25 million on expansion in 1956. The

PRECISE REDUCTION

for { EXPERIMENTAL LABS
PILOT PLANTS
TEST RUNS

American No. 13 Series CRUSHERS



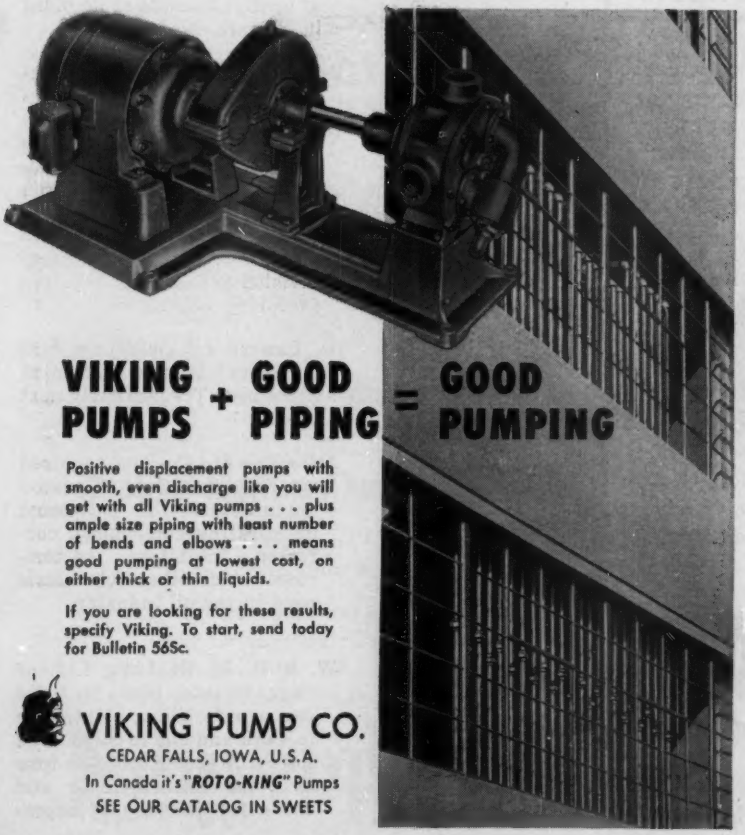
Designed for capacities beyond those of lab mills and below those required for large-scale crushing operations. Effectively used for wide range of materials. Up-Running Models (for maximum fines); Down-Running (for minimum fines). Equipped with rings or any of a full variety of hammers. Backed by over 40 years' experience in building reduction equipment. Write for Catalog on "13" Series Crushers.

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No obligation.

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Positive displacement pumps with smooth, even discharge like you will get with all Viking pumps . . . plus ample size piping with least number of bends and elbows . . . means good pumping at lowest cost, on either thick or thin liquids.

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Typical Examples of CO_2 at work

flavor saver



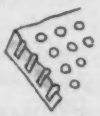
Oxidation causing air is ousted when foods are packaged in an atmosphere of CO_2 gas. 50% heavier than air, CO_2 gas effectively displaces this enemy of flavor and freshness. Cost? Amazingly low. Investigate.



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Of all weak acids, CO_2 is a bolt's best bet. As an acid in removing caustic soda after mercerizing, boil-off and vat dying, CO_2 has no equal. It cannot burn the cloth, is the easiest acid to handle and produces a superior "hand."

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CO_2 is extensively used in the manufacture of both foam rubber and foam thermoplastics. Among CO_2's most important applications in these fields are its uses as a foaming agent and as a neutralizer.

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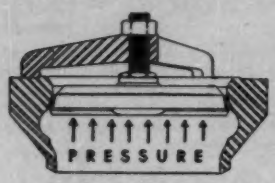
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FIRMS . . .

company has recently acquired Durethene Corp., makers of polyethylene film and tubing.

Ferro Corp., Cleveland, has announced a $240,000 building and equipment expansion for its color division.

Edward Valves, Inc. is doubling the size of its East Chicago, Ind., laboratory for research on steel valves.

Vacuum Metals Corp., Syracuse, N. Y., has started operation of a 2,200-lb. vacuum melting furnace designed to charge, melt, pour and remove ingots.

North American Aviation, Inc.'s Atomics International Div., Downey, Calif., has contracted with the Army Quartermaster Corps to study the most practical means of preserving food by atomic radiation.

Kolker Chemical Corp. has started full-scale production of methyl bromide at its plant in Newark, N. J.

Procter & Gamble Co. has announced a $1.8 million expansion program that will more than double the present size of its manufacturing, administration and research headquarters building in Cincinnati. The company has also formed a food products division to handle both manufacturing and sales.

St. Lawrence Cement Co. will complete a $27 million cement plant near Toronto early next year.

Atlas Powder Co. has acquired the Aquaness Corp., Houston manufacturer of petroleum dehydrating compounds, corrosion inhibitors, bactericides and other chemicals used in the oil industry.

W. & H. M. Goulding Ltd. of Cork, Ireland, plans to build two new fertilizer plants, one in Cork and one in Sligo. The first will produce 50,000 tons of compound fertilizer and the same quantity of super-

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At left: Jacketed 3-Way Plug Cock.

Below: Cutaway section of Jacketed Cock, showing packing gland construction.



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Jacketed Meter, with set-back register, for measuring viscous liquids.

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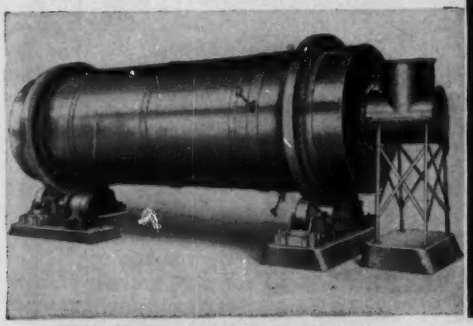
Regardless of whether the material is being heated or cooled in the processing, and what heating or cooling medium is being used, H & B jacketed fittings are available for all applications. Steam, hot water or hot oil may be used for heating, cold water or brine for cooling.

H & B can save you money on your jacketed pipe and fitting requirements because we buy all standard size pipe from the mill in carload lots, make our own special flanges in quantities, and are tooled up for making jacketed equipment at lowest possible price. Write for Bulletin J-50.

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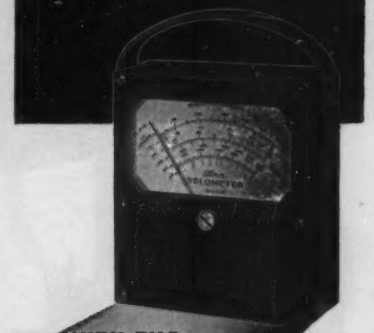
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FIRMS . . .

phosphate per year. The second will produce 20,000 tons per year of superphosphate.

Flexible Package Co., Chicago, has merged with its parent company, Bemis Bro. Bag Co. Its operations will be moved to Terre Haute, Ind., where most of the Bemis polyethylene bag manufacturing eventually will be consolidated.

Corpus Christi Refining Co. plans a $1.2-million expansion for its Corpus Christi, Tex., refinery.

Concrete Conduit Co., Colton, Calif., has purchased the facilities of Tellyer Concrete Pipe Co. with plants in El Paso, Tex., Albuquerque and Farmington, N. M., and Healdsburg, Calif.

Hannover-Hannibal A. G., Bochum-Hordel, Germany, which belonged to the Krupp concern before the war and is now up for sale, plans to establish a new 42,000-tons-per-year, $5-million plant for the production of ammonia on the plant area of Krupp-Kohlechemie GmbH.

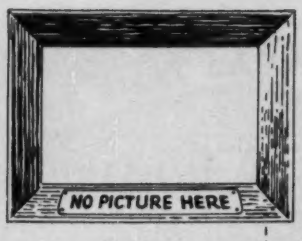
National Cylinder Co., Chicago, has purchased Denver Oxygen Co. and Western Oxygen Co., both Denver manufacturers of oxygen, medical gases and compressed gases.

Titanium Metals Corp. of America will install in its Pittsburgh mill a $3-million Sendzimir reversing cluster mill for cold rolling of continuous bands of titanium sheet in widths up to 49 in.

Cutter Laboratories, Berkeley, Calif., has purchased the Haver-Glover Laboratories, Kansas City, Mo., which makes veterinary surgical instruments and pharmaceutical specialties.

Resinite Corp. has started operations in a new $200,000 plant in Lincolnwood, Ill.

Lion Oil Co., division of Monsanto, has opened new chemi-



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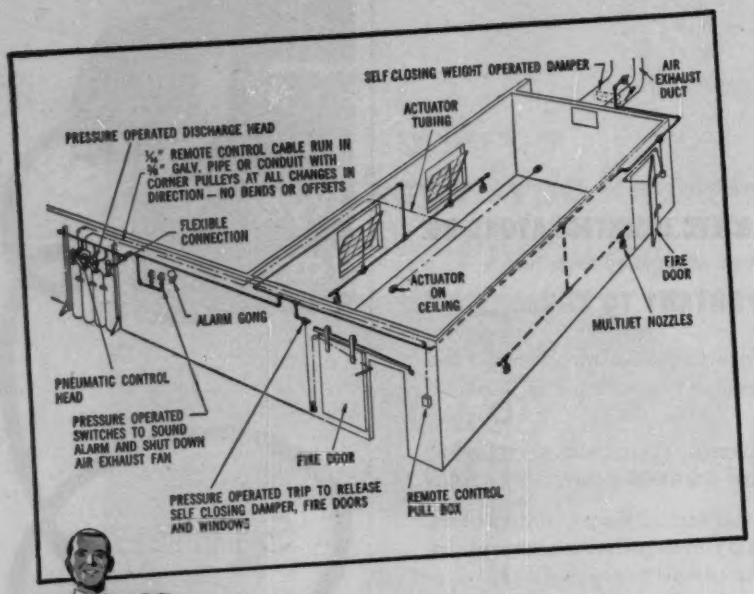
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The Kidde system diagrammed above shows how Kidde protection works. Patented Kidde rate-of-temperature-rise actuators trigger the system at the first sign of fire, insure *complete* 24-hour-a-day protection even in case of outside power failure! Kidde multijet nozzles—because of their unique design—distribute carbon dioxide in the most efficient way possible, snuffing out fires cleanly and quickly. And the new Kidde Pneumatic Discharge Head assures an instantaneous and complete discharge of CO_2 gas, also eliminates the need for clumsy mechanical triggering methods.

All moving parts of a Kidde system are completely enclosed for safety, have easy-to-read visual indicators which show at a glance whether system is "set" or "released." What's more, special Direction Valves on the Kidde system let you protect more than one hazard from the same bank of cylinders, a feature that means highly versatile fire protection.

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FIRMS . . .

cal sales offices in Des Moines, Iowa, and has moved its Montgomery, Ala., offices to Atlanta, Ga.

Container Corp. of America, Chicago, has started construction of a $925,000 plant near Renton, Wash.

Dow Chemical Co. plans to build a $3.5-million adminstration center at its Plant B in Freeport, Tex.

Kennecott Copper Co. will build a 100-ton-per-day contact sulfuric acid plant at Hayden, Ariz.

Shawinigan Chemicals, Ltd., Canada, is building a 75-ton-per-day contact sulfuric acid plant at Shawinigan Falls, Que.

Farben Fabriken Bayer Works has announced plans to spend about $50-million on expansion in 1956.

Industrial Filter & Pump Mfg. Co., Chicago, has started a $500,000 plant expansion.

American-Marietta Co., Chicago, has bought the Keystone Lime Works, Keystone, Ala., whose operations will be consolidated with those of A-M's Southern Cement Co. Div. in Birmingham.

Superior Tube Co. has begun construction of a $1-million plant and office building near the site of its present Wapakoneta, Ohio, plant which the new facilities will replace.

Felters Co. is building a $350,000 plant to produce its newly-introduced felt-like fabric which is a composition of textile fibers involving a resin binder.

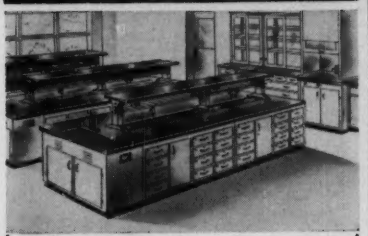
Western Coppers Mills, Ltd., is building a $3.5-million copper mill near Vancouver, B. C., to produce seamless copper tubing and pipe.

Dow Chemical Co. has opened a sales office in Buffalo to service a broad surrounding area in New York and Pennsylvania.

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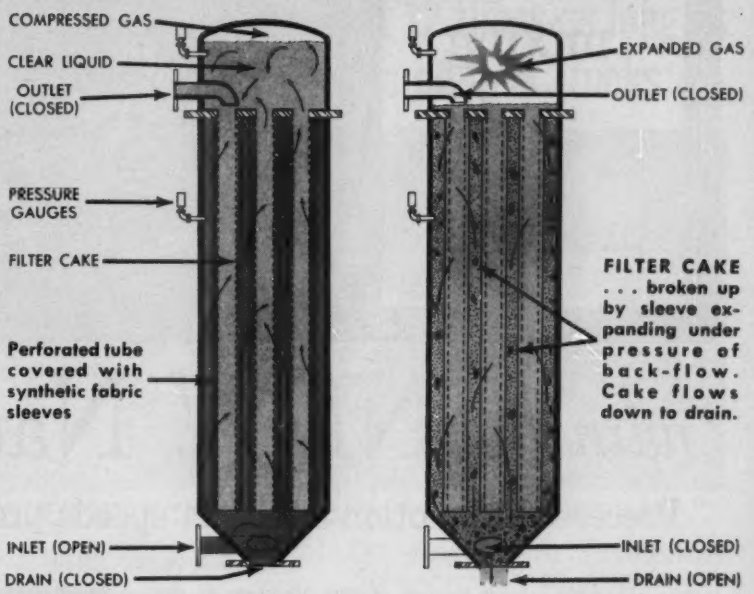
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- SMALL FLOOR SPACE
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Simply shutting off the outlet valve at the end of a filtering cycle prepares the filter for Hydra-Shoc cleaning. The air trapped in the filter chamber builds up under normal input pressure. Then a set of quick opening valves simultaneously shut off the inlet and open the drain. The air, suddenly released with a hammer-like blow, expands the fabric sleeves, instantly dislodging, and forcing the filter cake through the drain in seconds.



Special bulletin now available showing operating sequence, sectional drawings and principle of operation.

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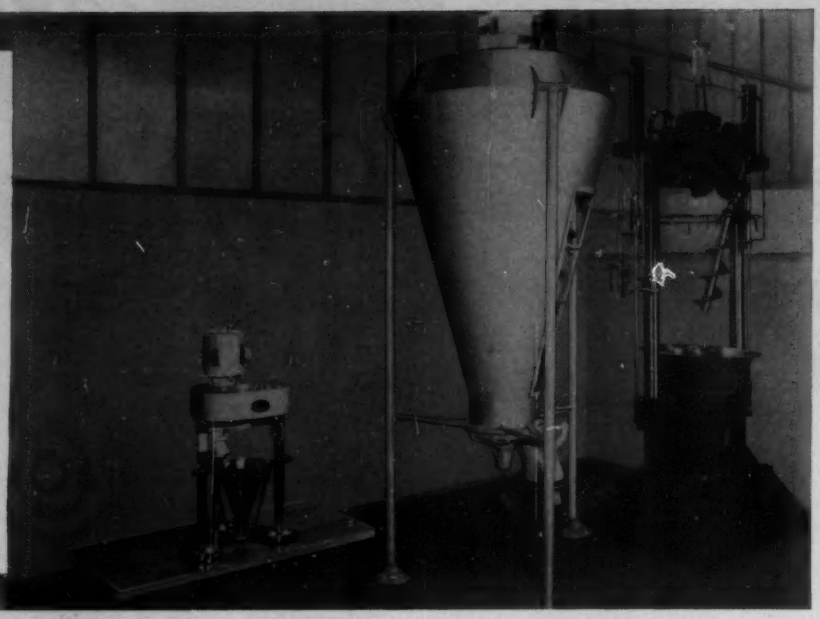
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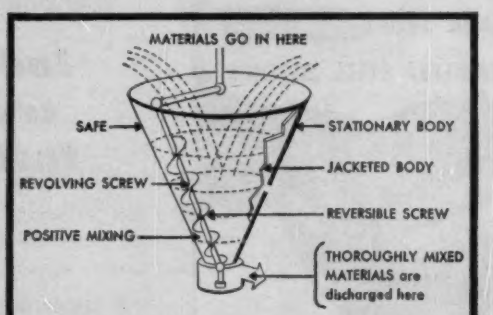
By shortening time cycles required for thorough mixing, the Nauta Mixer increases production. The revolutionary precessional motion means less power consumption. This is a combination that results in substantially lower costs.

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A quantity of your product ingredients can be mixed under actual production conditions in a Nauta Mixer now in the Buflovak Research Laboratory and Testing Plant, with positive results. Let us tell you about this service.

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The Buflovak Equipment Division of Blaw-Knox Company is the exclusive licensee for the Nauta Mixer. It is built to the same exacting standards for which Buflovak is famous in building evaporators, dryers, autoclaves, kettles and other equipment.

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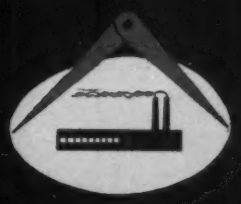
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HYPALON® hose carrying 98% sulfuric acid outlasts ordinary hose 16 to 1

Four months' service from a hose that loaded three tank cars a week with 98% sulfuric acid! That's the report from one southern phosphate company after switching to acid hose with tube of HYPALON, Du Pont's new synthetic rubber.

Before the change, regular acid hose had to be replaced after only one week . . . meaning just three tank-car loadings a hose. Yet the HYPALON tube hose was still in good condition after sixteen weeks. The difference lies in the superior resistance of HYPALON to acids—especially strong oxidizing acids.

Striking comparisons like this show what happens when HYPALON products are used for those *extra-tough* service applications. Replacement costs are cut . . . maintenance is drastically reduced. HYPALON products deliver top performance under the most severe conditions. High ozone concentrations, strongly oxidizing chemicals, high temperatures—rugged HYPALON can take them all and still give long-term service.

When you need a rubber product that must have *extra-high resistance* to deterioration, it will pay you to investigate HYPALON. Clip the coupon for further information.



ACID HOSE OF "HYPALON" in action, loading 98% sulfuric acid.

NEOPRENE coatings last 12 times as long as acid-resistant paints on tank trucks



FOR THE TANK SPLASH AREA (shown above), a black neoprene coating (brush) is used. For the rest of the tank, a grey coating is applied (spray).

Resist caustic soda and aluminum chloride; nitric, muriatic and other corrosive acids

Chemical Tank Lines, Inc. of Downington, Pa., reports that neoprene coatings applied externally have lasted 12 times as long as the best acid-resistant paints on the dome and center-sheet area of its acid tank trucks.

The company first tried a neoprene coating on only one of its tank trucks. The neoprene coating lasted over two *years* with only minor touching up and was still serviceable. The best acid-resistant paint previously used lasted only two *months*. This cost-saving performance persuaded Chemical Tank Lines to apply neoprene coatings to all of its 64 trucks.

First cost of the neoprene coatings is higher, says Earl D. Radcliffe, superintendent of operations, but "it looks like we'll only have to do the job every other year instead of six times a year. The net result should be that we keep our trucks painted for ⅛ the materials cost and 1/12 the labor cost." Mr. Radcliffe also reports that in addition to material and labor costs he loses $100 in revenue every time a truck is brought in for repainting. This amounts to $600 a year per truck with acid-resistant paint, only $50 a year per truck with neoprene coatings. And the company expects 4 years extra service from trucks coated with neoprene, thus reducing the cost of tank depreciation by $800 per year per tank.

Neoprene coatings are only one of many neoprene products that may help you reduce your company's cost of operation. Neoprene is also used in hose, belting, gaskets and scores of other products where resistance to chemicals, oil, grease and outdoor exposure is necessary, service conditions which quickly deteriorate ordinary rubber. Ask your rubber-goods supplier about neoprene, or mail the coupon below. We'll be glad to send further information.

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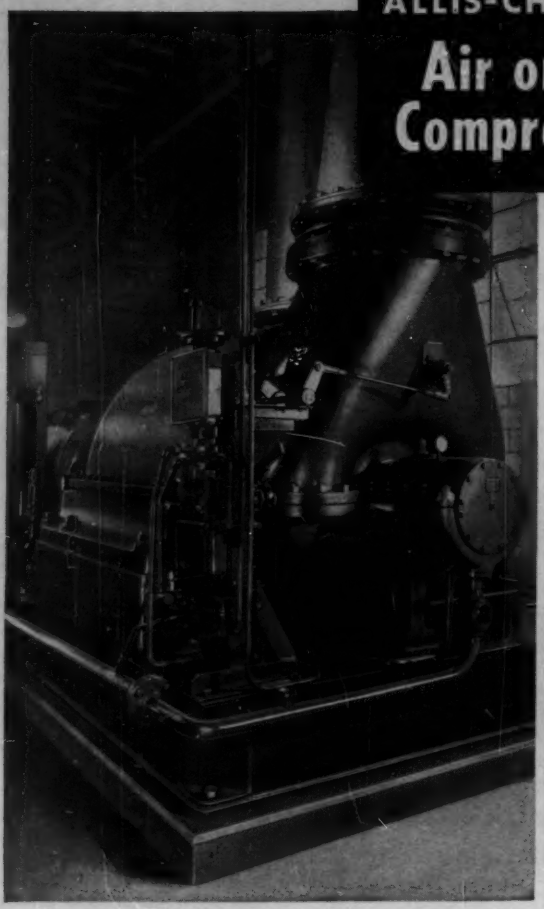
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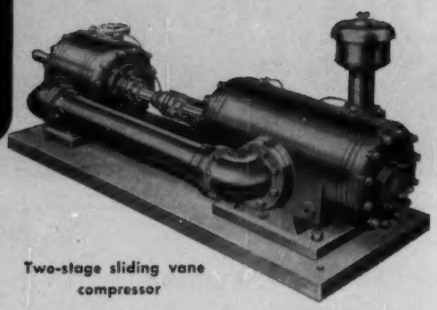
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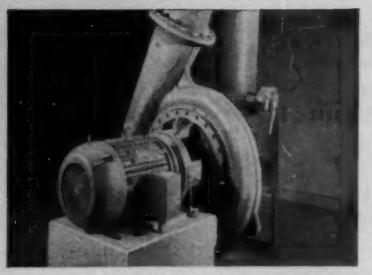


Four-stage motor-driven centrifugal air compressor rated 28,000 cfm inlet volume at 26 psig discharge pressure.



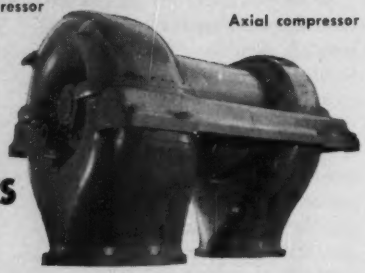
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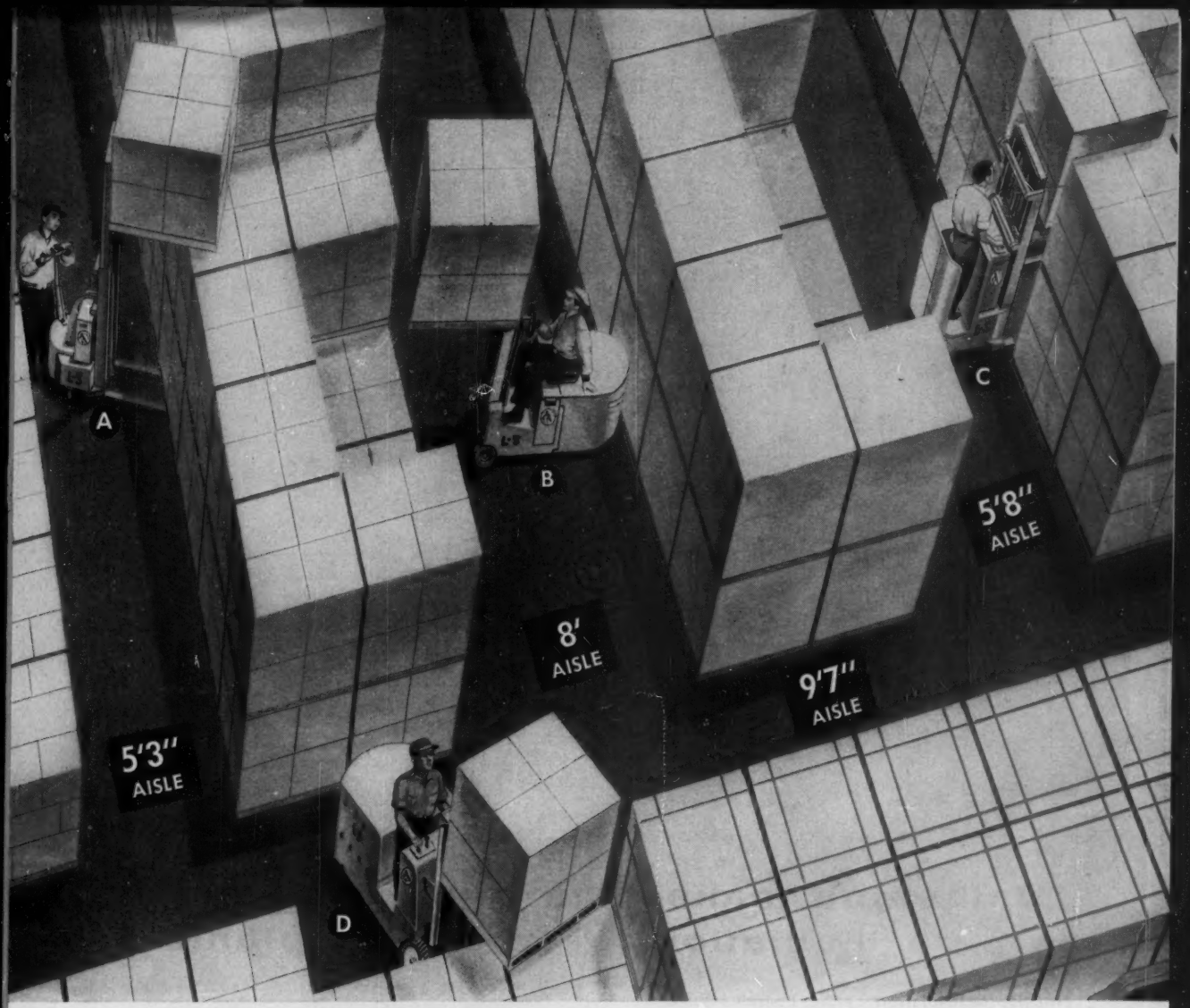
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"Aisle-matched" to reduce idle space

THE ARTIST'S DRAWING above shows that *whatever the width of your warehouse aisles there's a Lewis-Shepard Master Truck to match.* Shown are four L-S Master Trucks right-angle stacking the same 2000 lb., 40" long load in various size aisles. *You* decide the most practical aisle width . . . then select the Master Truck that matches *your* requirements.

Remember, Lewis-Shepard offers you *every type of truck made* — from lightweight two-wheelers to huge fork lifts . . . the *only* complete line of materials handling trucks on the market. And, because your local L-S Representative has this *complete* line, he's in a better position to advise you . . . he's not biased in favor of one type truck or design.

Dependable L-S Master Trucks are ordered and reordered by "blue-chip" companies. Recent reorders include:

Electrical Goods Mfr.	105 L-S in use — reordered 7
Rubber Mfr.	13 L-S in use — reordered 2
Spark Plug Mfr.	20 L-S in use — reordered 1
Aluminum Mfr.	14 L-S in use — reordered 4

Illustrated are: (A) JackStacker, 4000 lb. cap. electric "walkie"; (B) Model "J", 2000 lb. cap. riding type at ½ the usual cost; (C) Model "M", 3000 lb. cap., most compact of all riding types; (D) Model "E", 2000 lb. cap., fastest of all electrics.

Write for an L-S "Space Wheel" . . .
tells you aisles required for L-S Trucks and probable savings. Use the coupon.



LEWIS-SHEPARD

573 Walnut St., Watertown 72, Mass.

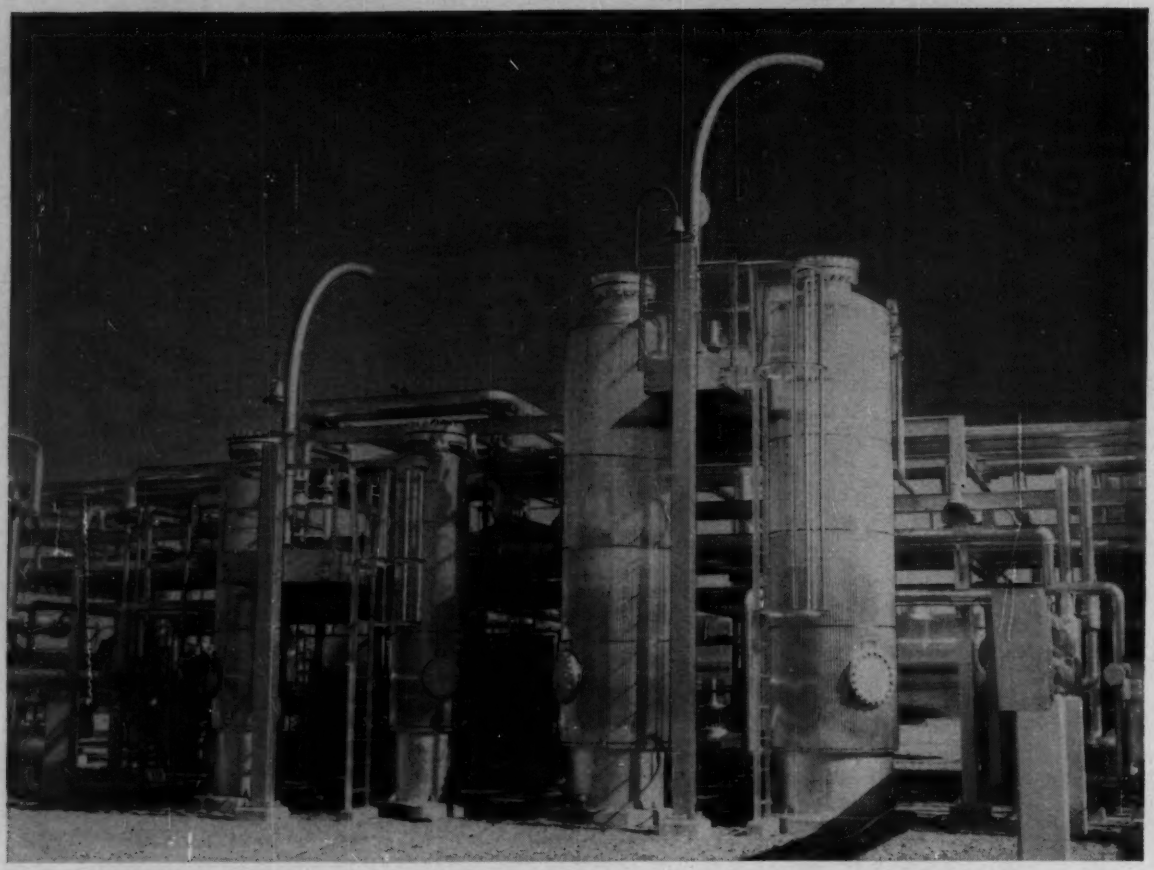
Please send

- ☐ L-S Space Wheel
- ☐ (A) L-S Master JackStacker Catalog #34
- ☐ (B) L-S SpaceMaster Model "J" Catalog #33
- ☐ (C) L-S SpaceMaster Model "M" Catalog #35
- ☐ (D) L-S SpaceMaster Model "E" Catalog #32

Name.....

Company.....

Address.....



Unibestos makes the big difference in pipe insulation for chemical plants

Not all pipe insulation is alike. There's a difference in insulating capacity . . . in durability . . . in ease of installation. And more and more chemical plants find Unibestos pays off on all three points. For Unibestos is made of Amosite, the long-fiber, quality asbestos that permits single-layer construction with superior insulating properties.

Single-layer Unibestos is easily installed right on the job. It's a strong, long-lasting insulation that withstands vibration and shock . . . resists moisture, steam, acid and chemical fumes. In fact, durable Unibestos is so durable that it can be removed and re-used many times over. Unibestos® pipe insulation is available in sectional form through 44" O.D.

Write for Free descriptive Bulletin 109C.

UNARCO

Joe Bestos says:



UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois

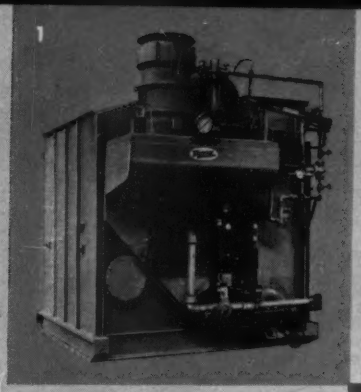
TITUSVILLE
THE TITUSVILLE IRON WORKS CO. TITUSVILLE, PA.
BOILERS Since 1860

Package Units

A Complete Selection

★ THE RIGHT TYPES
★ THE RIGHT SIZES
★ THE RIGHT BURNERS

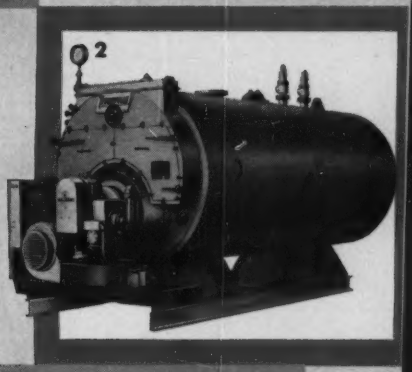
for every process power and heating need!

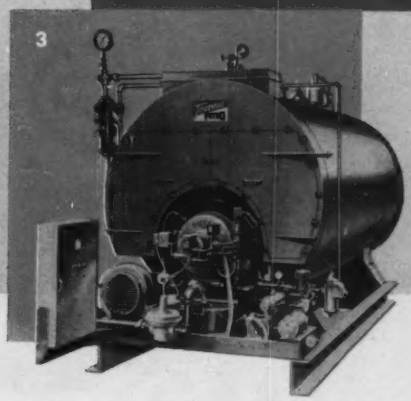


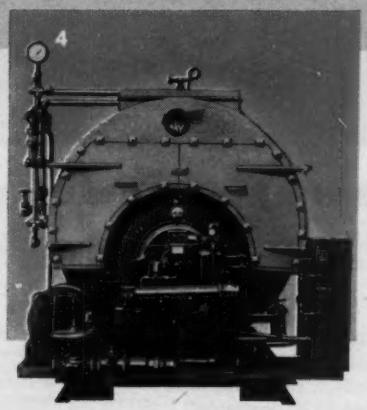
1. Titusville WTF Water Tube Steam Generator. Continuous steam capacity 7500 to 40,000 lbs per hr.

2. Titusville—Iron Fireman Boiler-Burner Unit.

3. Titusville—Petro Boiler-Burner Unit.







4. Titusville—Ray Boiler-Burner Unit.

Titusville Package Unit Boilers serve the chemical industries in a range covering all requirements, from the most complicated high pressure process and power loads to simple heating loads—smoothly, quietly, economically. All have modern automatic safety features; each is shop-assembled, shipped complete with all components installed, easily handled by lifting or skidding, and ready to go when field service connections are made. For prompt advice on the boiler type, size and burner combination precisely meeting your needs, write us!

THE Titusville IRON WORKS COMPANY

TITUSVILLE, PENNSYLVANIA

Manufacturers of A Complete Line of Boilers for Every Heating and Power Requirement

Offices in Principal Cities

Plants at Titusville, Pa. and Warren, Pa.

A Division of Struthers Wells *Corporation*

STRUTHERS WELLS PRODUCTS:

BOILER DIVISION
BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

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Crankshafts . . . . Hydraulic Cylinders Pressure Vessels . . . . Shafting . . . . Straightening and Back-up Rolls

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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

MACHINERY DIVISION
MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies



"FOAMGLAS solved our sphere insulation problem because it stays dry, stays effective"

states U.S. Industrial Chemicals Company

National Distillers Products stores anhydrous ammonia in four 55-ft. diameter spheres at their U. S. Industrial Chemicals Division plant in Tuscola, Ill. Pressure has to be controlled at 55 p.s.i. by holding temperature at 26°F. That calls for insulation that won't lose efficiency, and U.S.I. reports, "We solved the problem with FOAMGLAS."

They explain: "This cellular glass insulation isn't affected by spillage, acid atmospheres or moisture. That means we get dependable temperature control. Even under our blistering summer sun, heat gain in the spheres is only hundreds of B.t.u.'s per hour; not the usual thousands."

FOAMGLAS saved installation time and money for U.S.I., too. They found that "the light, strong, rigid blocks were easy to cut, shape and handle. Best of all, the material's high insulating value made only one 3-in. layer necessary."

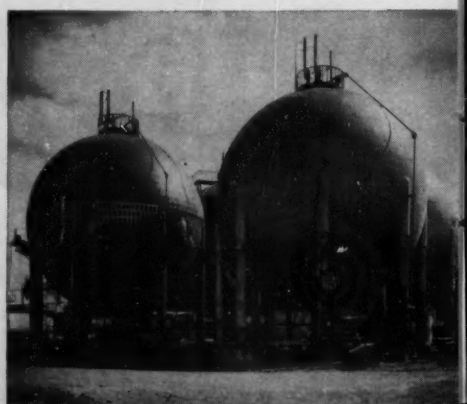
These benefits and more can be *yours* when you insulate spheres, piping, equipment or buildings with FOAMGLAS. Prove it yourself with a series of six simple tests easily performed in your own office. Write us today for a free sample and complete testing directions.

Pittsburgh Corning Corporation

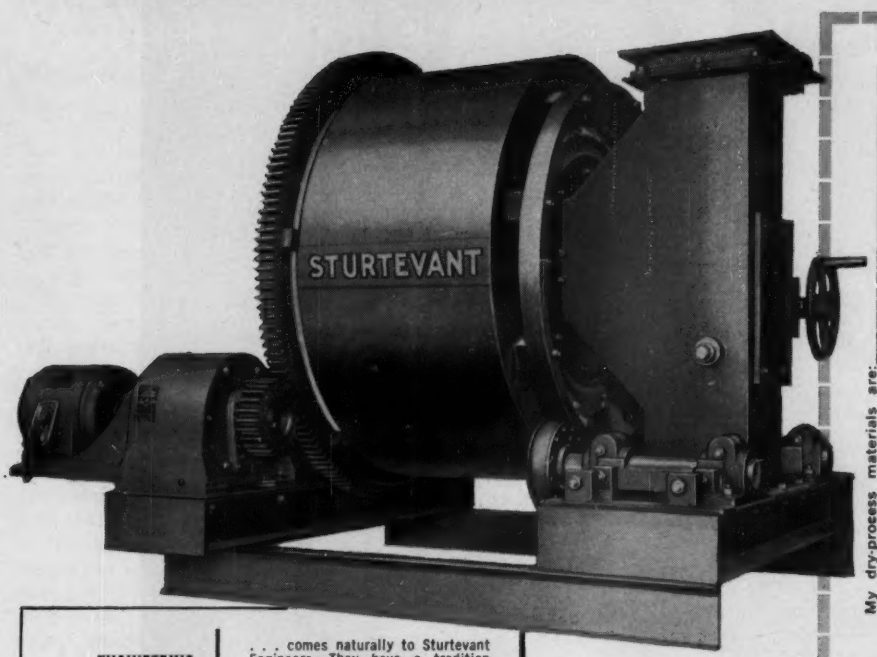
Dept. H-36, One Gateway Center
Pittsburgh 22, Pennsylvania

In Canada: 57 Bloor St. W., Toronto, Ontario

Installing FOAMGLAS on these four U.S.I. spheres was simplified by the material's light weight and handling ease. Each block of insulation was impaled on studs welded to the sphere plates. Joints were then sealed and asphalt cutback was sprayed on as a finish. Insulation Contractor was Heat Lock Corp., Indianapolis, Ind.



COSTS OF BETTER BLENDS CUT TWO TESTED WAYS



ENGINEERING BLENDING AND OTHER DRY PROCESSES TO SPECIFICATIONS

. . . comes naturally to Sturtevant Engineers. They have a tradition of solving dry-processing problems since 1873. Sturtevant custom-built equipment and plants are well-known for their low-maintenance-cost operation. If your problems include any of the processes listed on the coupon, it will pay you to investigate.

Sturtevant Dry-Batch Blenders:

1. **SPEED UP PRODUCTION WITH 4-WAY MIXING**
2. **SHORTEN SHUT-DOWNS WITH "OPEN-DOOR" DESIGN**

Batches from 500 to 40,000 pounds come out of Sturtevant Dry-Batch Blenders exactly as you want them. They are completely blended regardless of the varying weights, densities or fineness of the different ingredients. And no dust is lost in the process. **Four different vertical and lateral mixing actions** inside the sealed rotating drum achieve thorough blending in minimum time. Single lever control of a single gate speeds up loading and discharging.

"Open-Door" accessibility makes cleaning and maintenance a matter of minutes. This original Sturtevant advantage plus 75-year-tested rugged construction assures more output per machine-year. Check the coupon for more information.

STURTEVANT

Dry Processing Equipment

The "OPEN-DOOR" to *lower* operating costs over *more* years

CRUSHERS • GRINDERS • MICRON-GRINDERS • SEPARATORS
BLENDERS • GRANULATORS • CONVEYORS • ELEVATORS

My dry-process materials are:_____

Desired capacity is:_____

Name_____ Title_____

Firm_____

Street_____

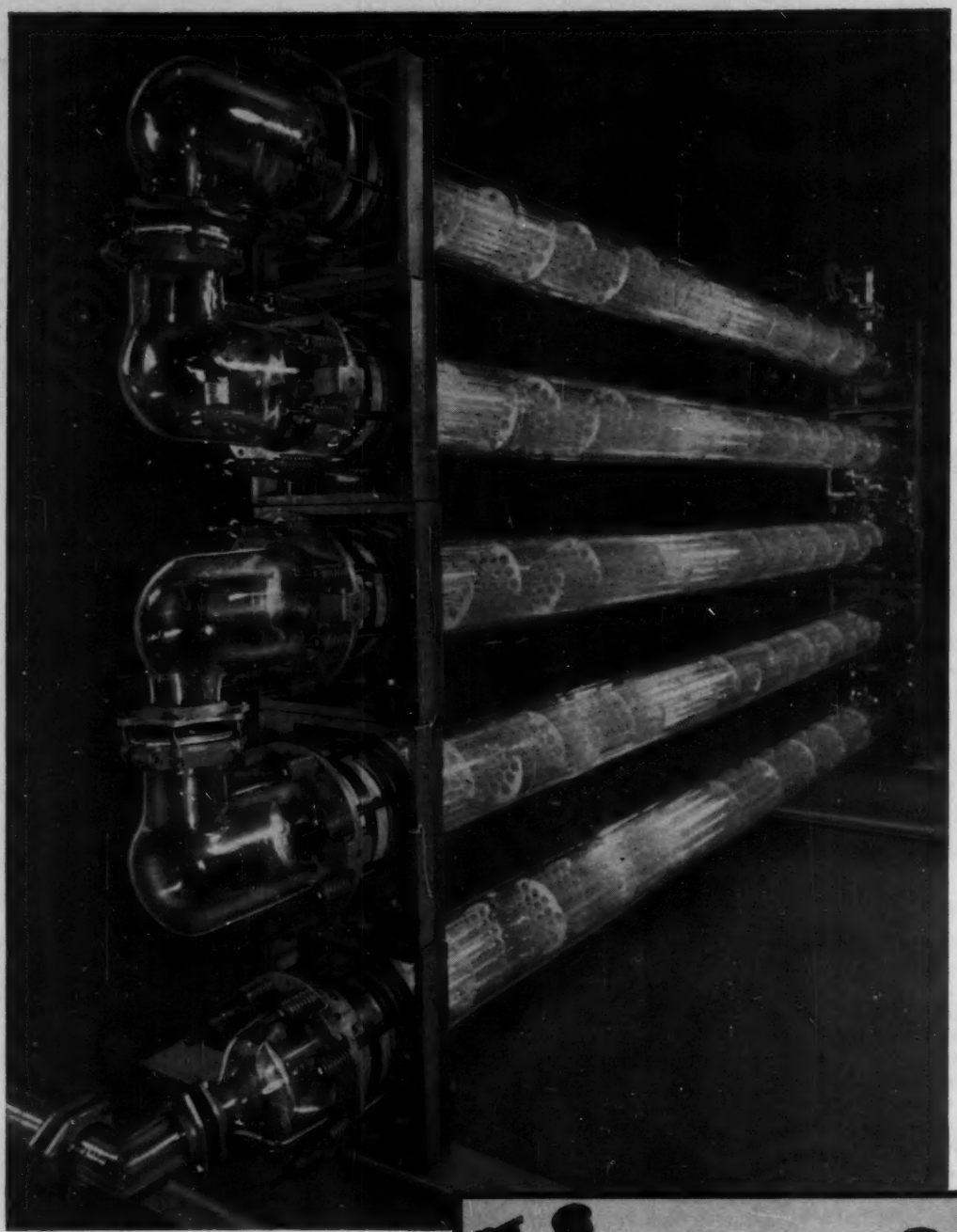
City_____ Zone____ State____

STURTEVANT MILL COMPANY, 100 Clayton Street, Boston 22, Mass.

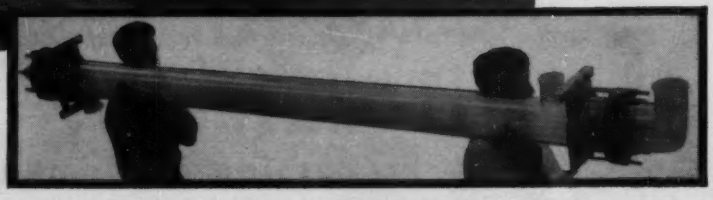
Please send me your bulletin on Dry Blenders ☐
Also bulletins on machines for:

☐ CRUSHING ☐ GRINDING ☐ PULVERIZING
☐ MICRON-GRINDING ☐ SEPARATING ☐ BLENDING
☐ SUPERFINE SELECTING ☐ GRANULATING ☐ CONVEYING

Heat, cool and condense corrosive



You can stack corrosionproof PYREX shell and tube heat exchangers like this. Modular design lets you quickly expand the system as you need. Manifolding lets you vary a group according to fluctuating process requirements. Easy cleaning lets you switch quickly from one product to another without down time, so you can handle incompatible products in the same units.



The 50 sq. ft. model weighs 175 lbs. dry, the 13½ sq. ft., 45 lbs. Two men can handle either size without hoist or crane.

fluids safely in PYREX brand modular shell and tube heat exchangers

New design gives you lasting relief from costly heat transfer problems

Metal-sensitive fluids are safe, too

Now you can heat, cool, and condense corrosive fluids with the ease you handle noncorrosives.

In the PYREX brand shell and tube heat exchanger nothing can corrode because fluids contact only glass, Teflon and ceramic materials. And because there is no exposure to metallic parts, fluids sensitive to metals are safe, too.

No heat-flow barrier

Small diameter, thin-wall PYREX tubes give you over-all heat transfer coefficients as high as 195 b.t.u. per hour, per square foot, per degree F.

The smooth surface of glass helps keep fluid velocity high. Less stagnant fluid film builds up between the fluid on either side of the tube wall. Glass' smoothness provides a high degree of resistance to scale and algae. (See diagram below right.)

By eliminating these common impediments to heat flow, PYREX shell and tube heat exchangers *keep* their high efficiency permanently.

Wide versatility

PYREX brand shell and tube heat exchangers are built as standard modular units. You can add units easily as demand grows. You can circuit multiples in series and parallel flow combination. And you can vary capacities according to processing load with external manifolding of any or all sections of the assembly.

Built to bring you savings

Mass production gives you low first cost with all the advantages of custom design without manufacturing delay. Installation costs are low because two men handle these units without hoists or cranes. And the mounting brackets we furnish are the only supporting framework needed.

You get low maintenance costs due to the absence of corrosion and the unlikelihood of fouling. Even if some scaling should appear, recirculating dilute HCl removes it without down time or mechanical cleaning. External fittings are either Monel metal or epoxy coated cast iron.

Two models in two sizes

You can get the new PYREX brand modular shell and tube heat exchanger units in 50 sq. ft. or 13½ sq. ft. capacities in standard or regenerative models. The standard model takes corrosive fluids on the tube, noncorrosives in the jacket. The regenerative takes corrosives on both tube and jacket sides.

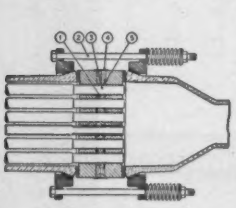
Get this new design manual

The "Design Manual for PYREX brand Modular Shell and Tube Heat Exchanger Units" is a detailed engineering reference guide. It shows you how to select units, lay out systems, engineer systems and order equipment for processes using these new heat exchangers.

To get your copy of this handy guide to economical and efficient heat interchange in your plant, send in the coupon. Or, if you have questions about specific problems, write to Plant Equipment Sales, Corning Glass Works, Corning, New York. They will see that you get answers.

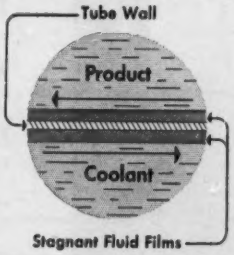
DIAGRAM OF HEADER ASSEMBLY—This design gets rid of the troublesome floating head and packing gland you usually have to cope with in shell and tube heat exchangers.

The unique "fluid" seal between the shell side and the tube side is effected by a Silastic sealer sheet (1). This acts as a fluid and is put under fluid pressure by tightening the flange bolts (2). The fluid is completely contained in the cavity formed by the tubes (3) and the retainer ring (4) around the outside of the tube sheets. The Silastic sealer sheet is compressed against the Teflon sealer sheet protector (5), which presses against the precision-finished tube ends, creating a leak-proof seal.



GLASS AS A HEAT TRANSFER AGENT—In many cases the principal barriers to heat flow between fluids are stagnant fluid films adjacent to tube walls and scale deposits on the walls. Usually, the thermal conductivity of the tube material is of relatively little importance.

Because glass has hard, smooth surfaces, it provides a high degree of resistance to scale and algae deposits. It also keeps fluid velocities high, reducing stagnant fluid films which act as insulators, impeding heat transfer.



CORNING GLASS WORKS
Corning, New York

Corning means research in Glass

CORNING GLASS WORKS, 13 Crystal Street, Corning, New York

Please send me a copy of your "Design Manual for PYREX brand Modular Shell and Tube Heat Exchanger Units."

Name.....Title.....

Company.....

Street.....

City.....Zone.....State.....



we never underestimate the creative in construction...

Building petroleum refineries, petrochemical and chemical plants requires complete understanding of practical construction techniques. You know, and we know, that there is no substitute for experience, a thorough knowledge of tried-and-proved methods, in this business. But, there is an important something beyond this, too.

It is the "creative sense" ever present at Procon, the constant seeking for better, more practical, more economical ways to build the most efficient installations for our clients. We are ready to apply this creativeness to your construction problems.

PROCON *Incorporated*
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PROCON (*Canada*) LIMITED
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WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

Want control for Water Heaters, Heat Exchangers, Processes?

call POWERS

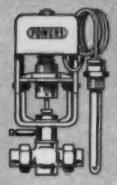
FLOWRITE
One of Powers Premium Quality Diaphragm Control Valves. They're simple, sturdy and dependable.



Over 60 Years of Temperature and Humidity Control

(c28)

You Will Insure Better Temperature Control IF— you use the right type regulator and proper size control valve. Whether a simple self-operating regulator shown at left is required or the air operated controls featured here . . . you can get both types and others from Powers. For further information call or write our nearest office.



Powers ACCRITEM Temperature Regulator and FLOWRITE Valve—the right combination for many control problems where pressure and load conditions fluctuate widely, also for control of large size valves.

Over 50 Years Experience making this type of regulator

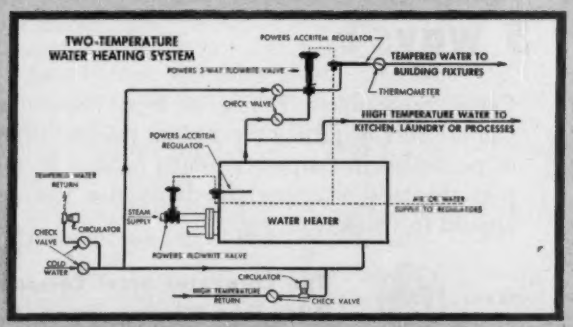


Control Point easily changed

Air or water operated

Ranges 50 to 250°F—150 to 350°F

VALVES: Available in a variety of body types and inner valves.

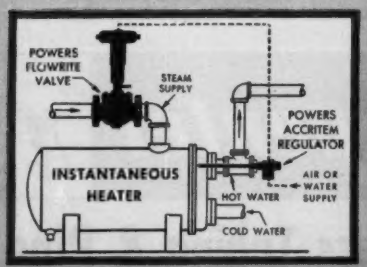


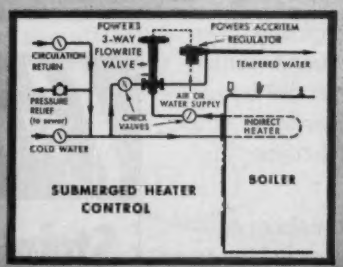
ACCRITEM TEMPERATURE REGULATOR

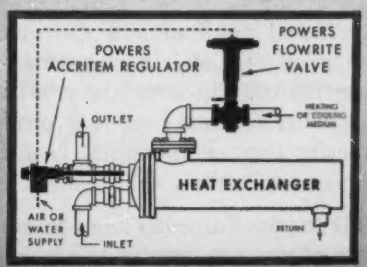
Gives Close Control and Years of Dependable Service.

- Has Adjustable Throttling Range and Calibrated Dial.
- Simple, Durable Construction assures years of trouble-free service.
- Easy to Install • Direct or Reverse Acting, reversible on the job.
- Small Size: Regulator head is 2⅞" wide, 3⅛" high, bulb is 12" long with ½" IPS Connection.

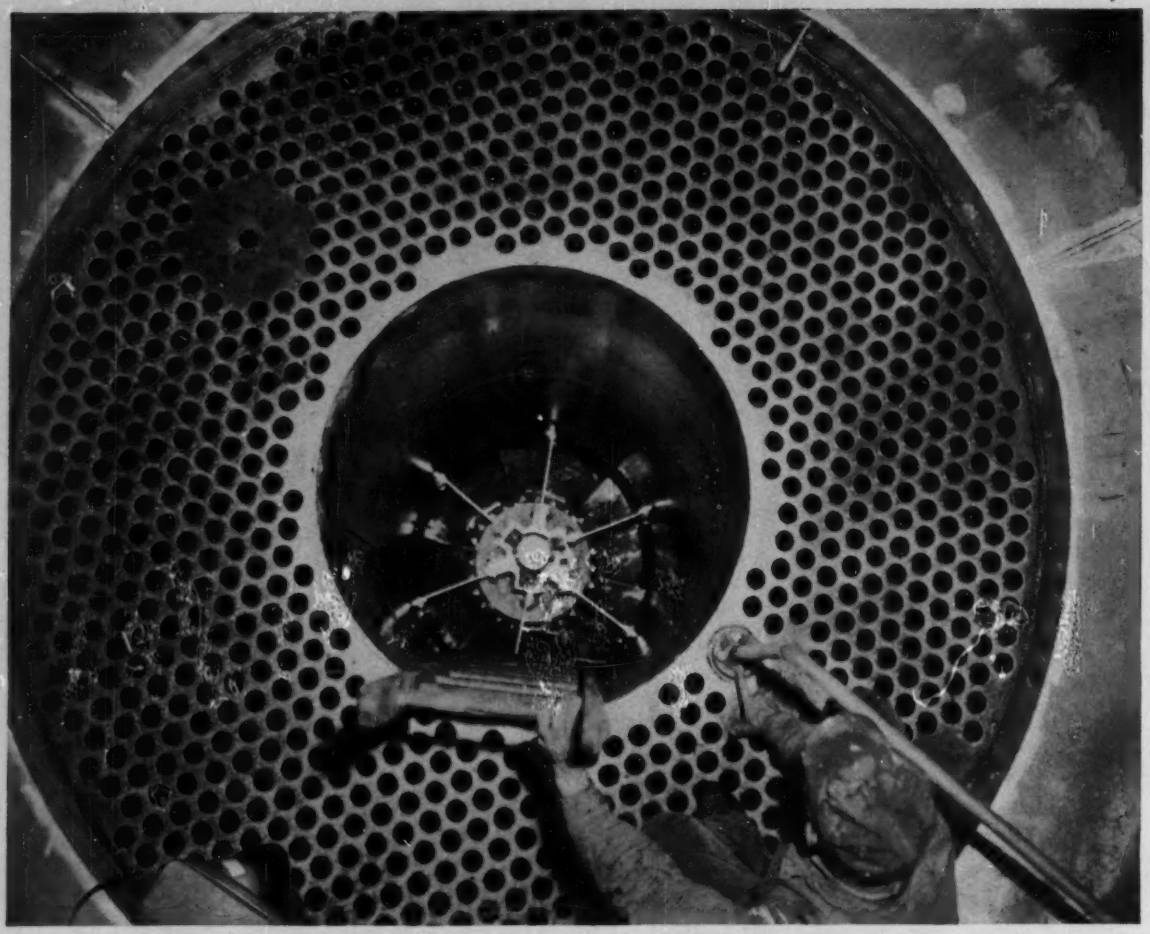
Fully Described in Bulletin 316. Write for a copy.







THE POWERS REGULATOR COMPANY | Skokie, Ill. • Offices in Chief Cities in U. S. A. Also Canada and Mexico • See your phone book



Switching to *Carpenter* Stainless Tubing pays off 5 ways!

How can *you* use the five advantages gained by a prominent distillery when it changed to Carpenter Stainless Tubing for a new stillage evaporator?

Twice the service life . . . greater operating efficiency . . . lighter weight . . . greater carrying capacity . . . and a higher cost-life ratio are the proven results obtained with more than a mile of Carpenter Stainless Tubing in this evaporator.

Additional proof of how Carpenter quality pays off on job after job is available from your Carpenter Distributor. Discover the profitable difference Carpenter can make on your own processing and transfer lines, evaporators, heat exchangers and similar applications.

Talk to your Carpenter Distributor now about cost-savings you may be able to obtain by switching to Carpenter Stainless Tubing or Pipe. Remember, you are sure of getting the highest possible degree of perfection in Carpenter tubing because it must pass the most exacting non-destructive test ever applied to stainless tubing.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N.J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

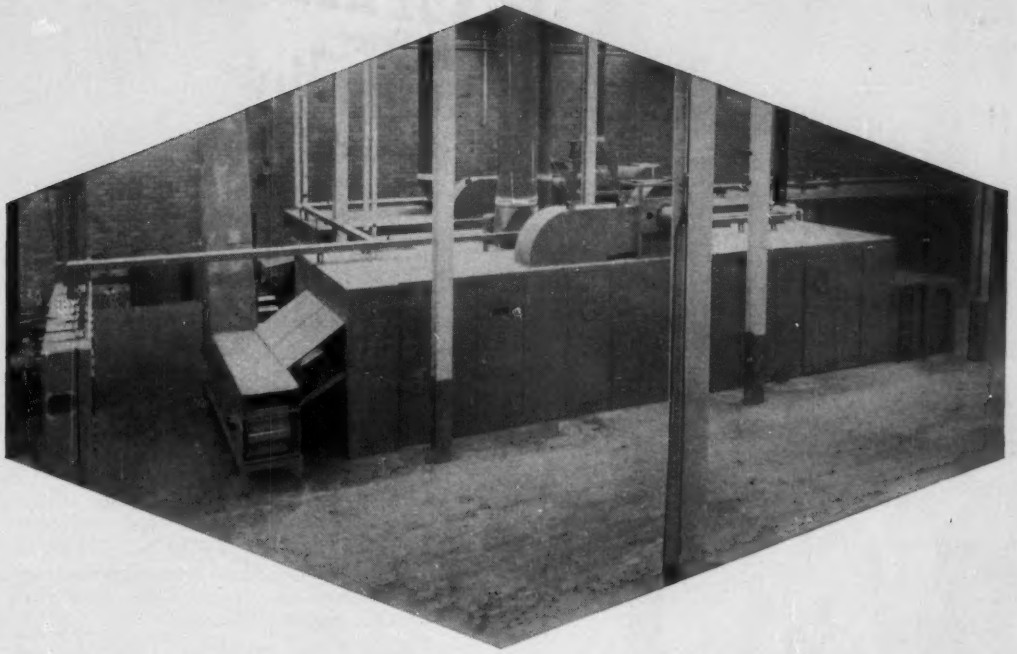
Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

A Proctor

DRYING RANGE means HIGHEST PRODUCT UNIFORMITY!



Efficient drying per pound of product can often *mean more direct profit to you* than an increased sales volume! Proctor equipment provides the control, flexibility, and construction features *essential* to profitable drying performance. The result—increased yield of highest quality product. Write or phone *today* for complete information.

Product Uniformity is of utmost importance to every food processor, at all stages of processing.

Shown above is one of many Proctor & Schwartz dryer installations in one of the country's larger food plants—typical of the many in use in the food industry today. Here, because of Proctor drying skills, uniformity of color, taste, and overall customer appeal is maintained at uniformly highest levels—yields are greatly increased!

★ PROFITABLE OPERATION
★ INCREASED YIELD
★ GUARANTEED PRODUCT QUALITY
★ "W/M" CONSTRUCTION
★ FLEXIBILITY OF OPERATION

PROCTOR DRYING EQUIPMENT FOR THE FOOD AND PROCESS INDUSTRIES

• Tray Dryers • Truck Dryers • Pre-Forming Feeds
• Continuous Conveyor Dryers • Spray Dryers

Proctor

PROCTOR & SCHWARTZ, Inc.

Manufacturers of Industrial Drying Equipment and Textile Machinery, Philadelphia 20, Pa.

F&P Flowmeters



FROM
HATBORO, HOUSTON, CHICAGO
OR LOS ANGELES

Predictable performance floats permit Flowrator Meters with true percentage scales to be carried in stock. You benefit from F&P's years of hydraulic research by getting accurate meters quickly.

Greater flexibility of use is assured by the ease and simplicity with which new flow factors may be determined on changes in fluid service. Capacity may also be altered by revising metering float weight and yet, the same metering accuracy is maintained.

Advantages of specifying F & P Meters:

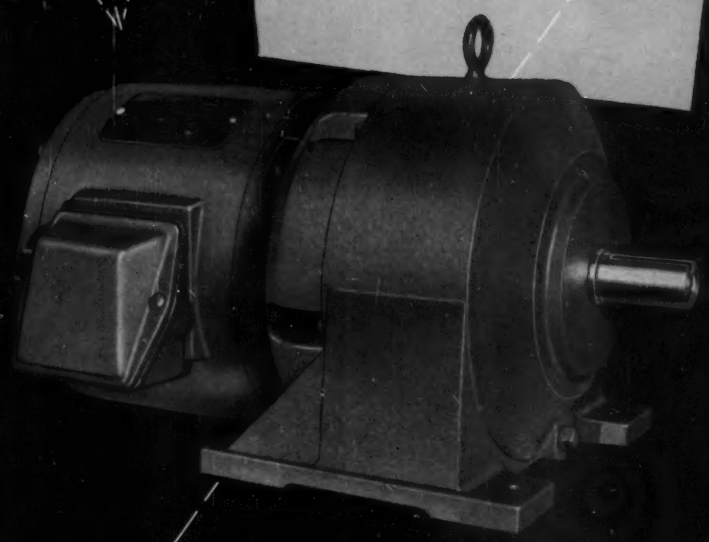
- Highest quality—same as made-to-order, extended shipment instruments.
- Prompt delivery—most items shipped the same day the order is received.
- Economy—standardization on percentage scales and interchangeable parts, minimizes spare part problems.

A wide variety of flow indicators, purgemeters, transmitters, recorders, controllers and pressure instruments are available from stock. Write today for Catalog #2 and complete information.

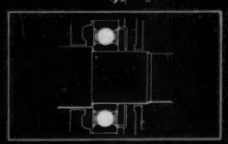
FP FISCHER & PORTER CO.

136 County Line Road, Hatboro, Penna.

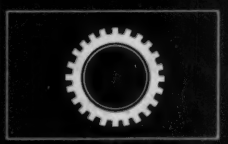
Don't overlook what you can't see



You can't always see what makes a gearmotor outstanding. It's the attention paid to small design details that makes the difference. Here are a few of the details that make the new Reliance Gearmotor stand above the rest.



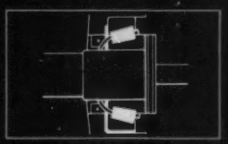
FOOLPROOF METERMATIC motor bearing lubrication and oil bath gear lubrication for long-life protection against wear.



INDUCTION HARDENING of the tough alloy steel gears gives a perfect combination of wear resistance and strength.



SIMPLIFIED GEARING with few moving parts reduces friction losses and lessens chances of breakdown.



THRUST BEARINGS handle heavy overhung loads safely by placing strain on the frame instead of the shafts.

Find out the complete story for yourself— contact your Reliance representative or write for Bulletin E-2408.

E-1509

REDUCE SPEED

RELIANCE ELECTRIC AND ENGINEERING CO.

CLEVELAND 10, OHIO · OFFICES IN PRINCIPAL CITIES

Canadian Division: Welland, Ontario

Chosen All Over the World



Presenting the complete answer to every separation problem of the process industries.

FILTERS • DRYERS • CENTRIFUGES

For batch, continuous or fully automatic operation. Produced by an Organization with more than half a century of experience.

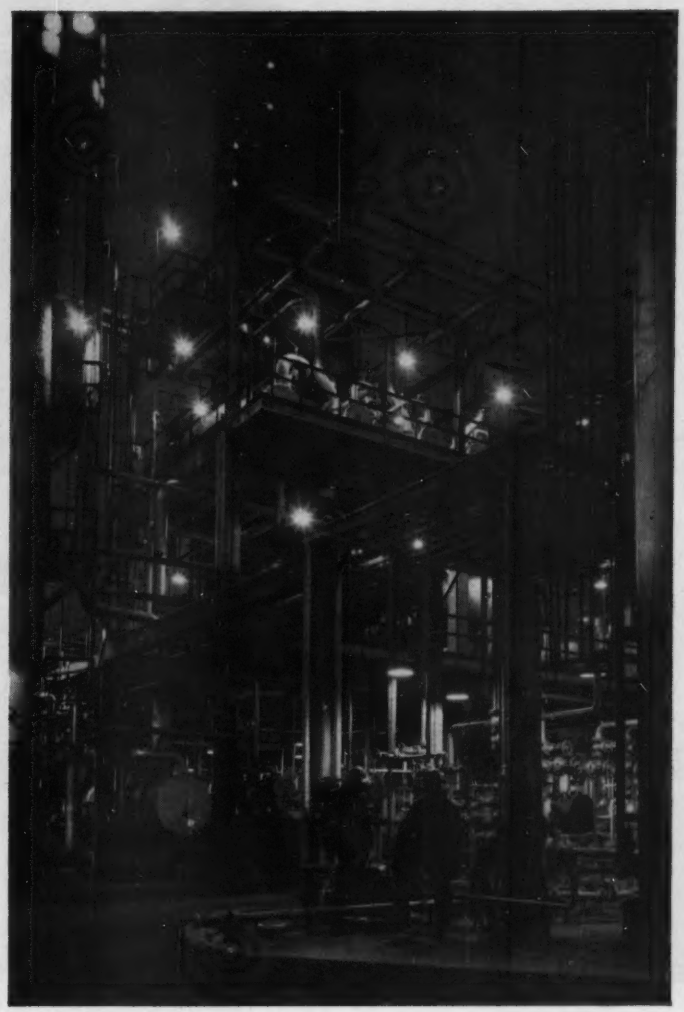
Write for descriptive Bulletins

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ON-STREAM...DAY AND NIGHT

...to serve your needs for SINCLAIR Toluol, Xylol and Paraxylene



The Udex extraction unit of Sinclair Refining Company at its refinery at Marcus Hook, Pa., operates on-stream 24 hours a day. Toluol, Xylol and Paraxylene produced from this Udex unit meet important industrial needs for high purity petrochemicals in quantity.

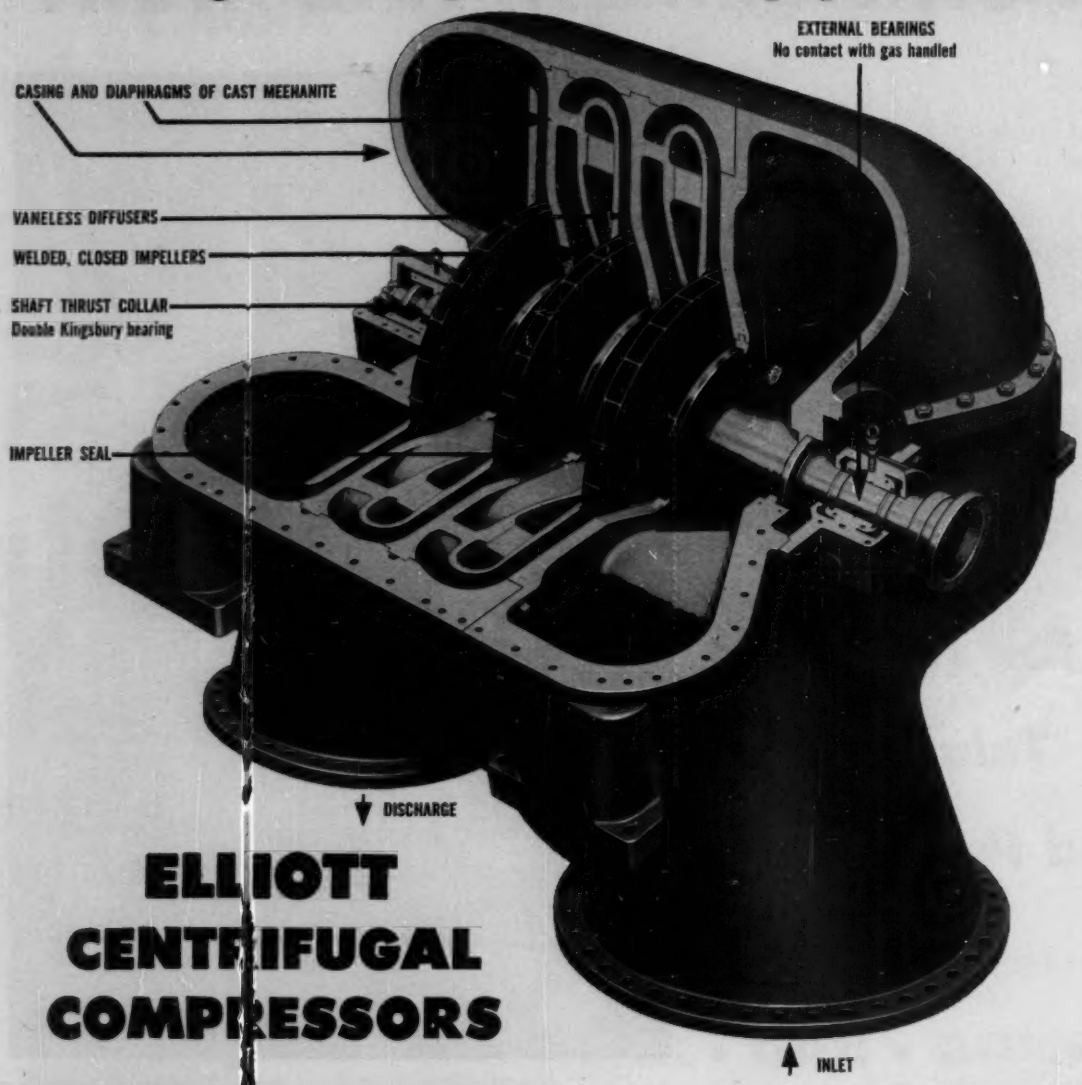
When your manufacturing processes call for fast and reliable service and top quality in aromatic hydrocarbons, Sinclair Chemicals, Inc. is ready to serve you. For complete information call or write to:

SINCLAIR CHEMICALS, INC.

(Affiliate of Sinclair Refining Company)

600 Fifth Avenue, New York 20, N. Y. • Phone Circle 6-3600
155 North Wacker Drive, Chicago 6, Illinois • Phone Financial 6-5900

Pointing the way to non-stop performance



ELLIOTT CENTRIFUGAL COMPRESSORS



ONE OF THE LARGEST CENTRIFUGAL COMPRESSORS IN SERVICE TODAY
This Elliott compressor, installed in a southwest refinery, handles 135,500 inlet cfm of air at 22.0 psig discharge pressure.

Take a good, close look at this Elliott Multistage Centrifugal Compressor. Note its simplicity and ruggedness of design and construction. It's easy to see why these compressors have been setting non-stop service records in refineries. They're built for the "long run."

Elliott Centrifugal Compressors are available in both single and multistage types, for inlet capacities up to 175,000 cfm, and discharge pressures up to about 2000 psig. Drive may be turbine, gear-motor combination or direct-connected motor, all built by Elliott. For details write Elliott Company, Centrifugal Compressor Dept., Jeannette Pa.

ELLIOTT Company

P5-1A



An important new source of

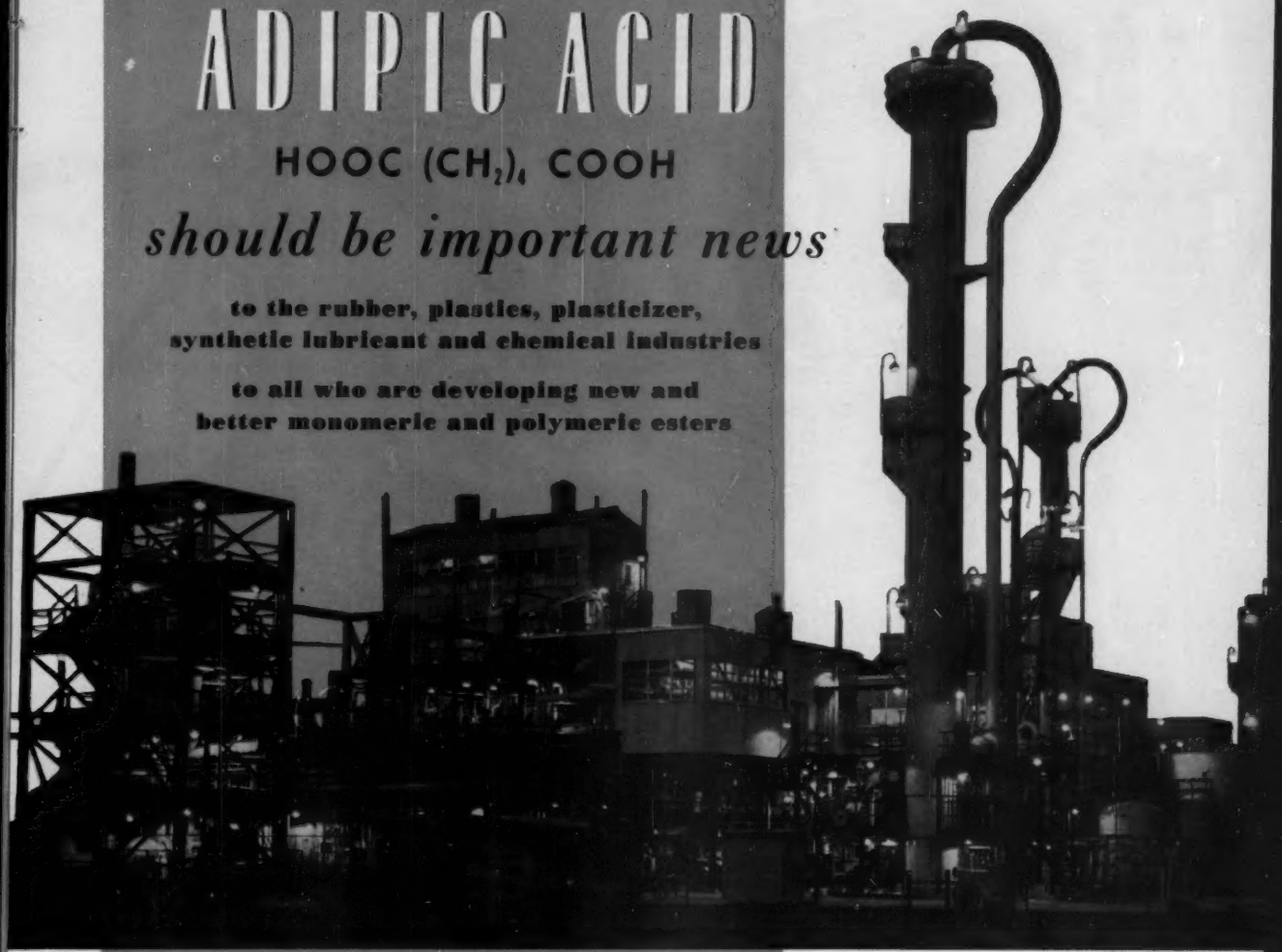
ADIPIC ACID

$HOOC(CH_2)_4COOH$

should be important news

to the rubber, plastics, plasticizer, synthetic lubricant and chemical industries

to all who are developing new and better monomeric and polymeric esters



National Aniline's new Adipic Acid plant at Hopewell, Virginia is important to America and to American industry. For its production of this versatile dicarboxylic acid will be both substantial and basic.

Through Allied Chemical resources, it is completely integrated right back to the most basic raw materials. Through Allied Chemical research, the manufacturing process is efficient, uniform, continuous. Through modern plant engineering and construction, its output will be competitive in every respect.

From present and potential users of ADIPIC ACID, we invite inquiries for samples, technical data and quotations on price and delivery.

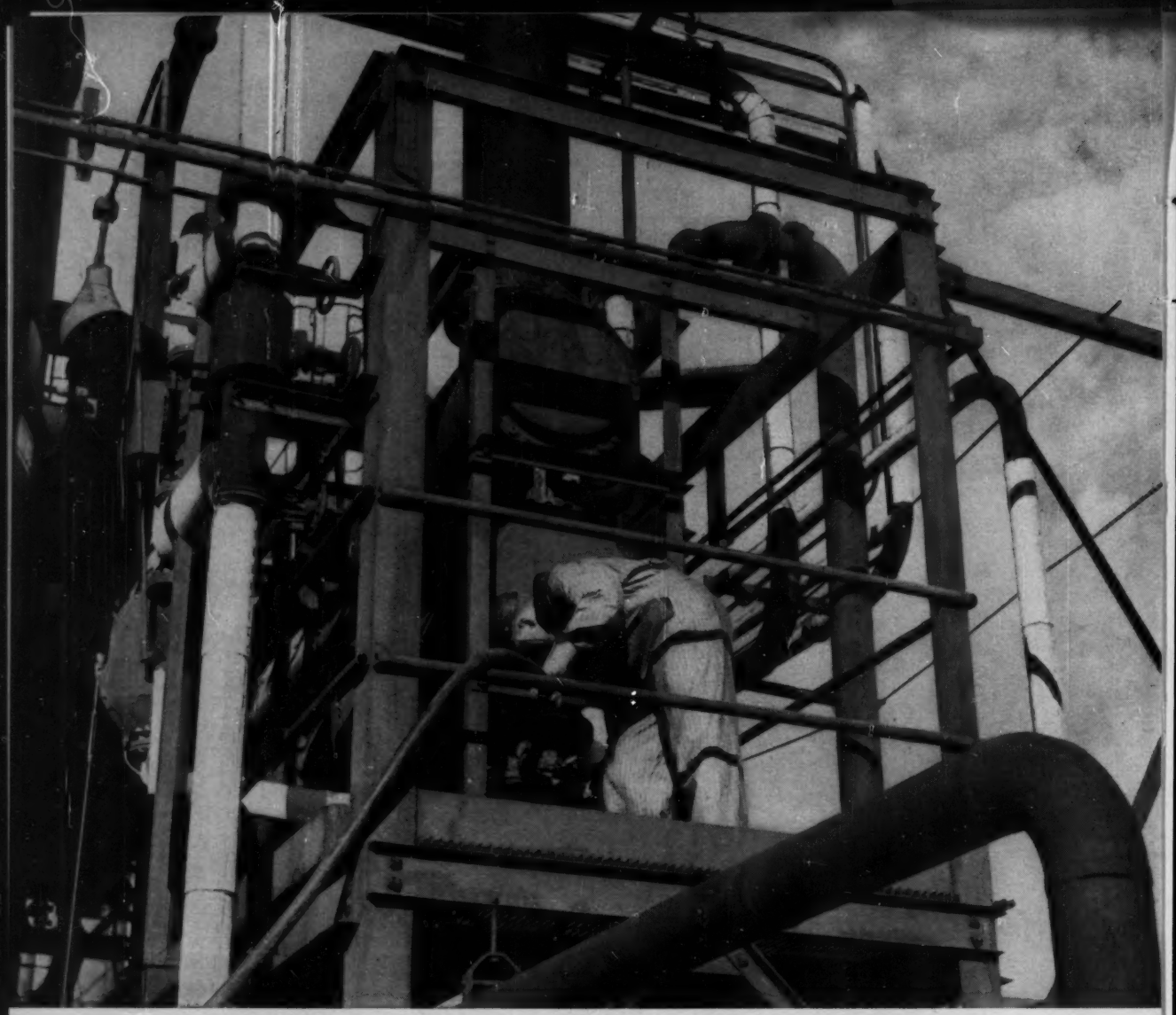
SEND FOR TECHNICAL BULLETIN I-12

This comprehensive 8-page technical bulletin on National Adipic Acid gives physical and chemical properties; principal reactions on the carboxyl and alpha methylene groups; solubility curve, and suggested uses with copious literature references. Your copy will be sent without obligation on request.

NATIONAL ANILINE DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Allied Chemical

Boston Providence Philadelphia Chicago San Francisco Portland, Ore. Greensboro Charlotte Richmond Atlanta Los Angeles Columbus, Ga. New Orleans Chattanooga Toronto



There's too much at stake —clean it right

Chemical cleaning involves costly equipment and often work stoppages. It's a job for experts. Let Dowell protect that equipment and keep production losses to a minimum when you have scale or sludge problems.

In over 15 years our trained engineers have serviced virtually every kind of equipment in plants, mills and refineries throughout industry. In fact, Dowell has cleaned over 10,000 boilers alone!

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Call the nearest of more than 165 Dowell offices. An experienced engineer will be glad to talk over and help you with your cleaning problems any time — at no obligation. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. C-33

chemical cleaning service for industry

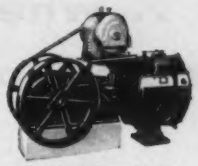
DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

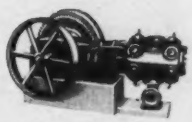
Heavy-duty
ES compressors

provide maximum efficiency in a WIDE RANGE OF APPLICATIONS

. . . with unusual flexibility of drive and cylinder arrangements



OVERHEAD MOTOR

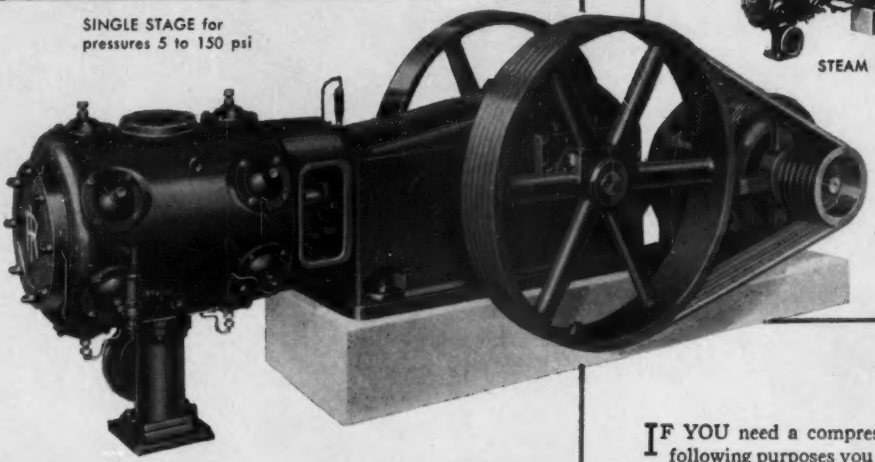


DIRECT-CONNECTED SYNCHRONOUS MOTOR

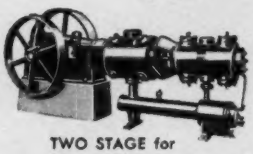


STEAM DRIVE

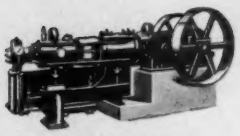
SINGLE STAGE for pressures 5 to 150 psi



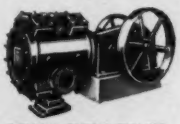
V-BELT DRIVE



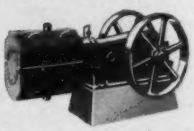
TWO STAGE for 150 to 500 psi



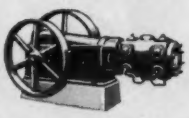
THREE STAGE for 500 to 2500 psi



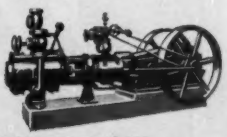
DRY VACUUM PUMPS . . . single or two stage



STEAM-PRESSURE BOOSTERS



NON-LUBRICATED CYLINDERS for oil-free air or gas



REFRIGERATION UNITS for ammonia or other refrigerants

IF YOU need a compressor for any of the following purposes you should consider the Type "ES" compressor . . . a standardized, yet extremely flexible compressor built by Ingersoll-Rand, the pioneer compressor builder.

- To compress air or gas to any pressures between 5 and 2500 psi, or for pulling vacuums. (Stock cylinders are normally available for all frame sizes, see illustrations.)
- For capacities requiring from 7½ to 150 horsepower. (Six frame sizes are available.)
- For continuous full-load operation day after day, week after week.
- For handling poisonous, inflammable, or other gases where leakage must be avoided.
- Where compressed air or gases must be free of all traces of oil. (Type NL cylinders require no oil, glycerine, grease or water for lubrication.)
- Where a future change in pressure conditions may call for a change in cylinder sizes.
- Where power cost is an important factor.
- To act as an economical standby unit for larger compressors whose full capacity is not required at all times.

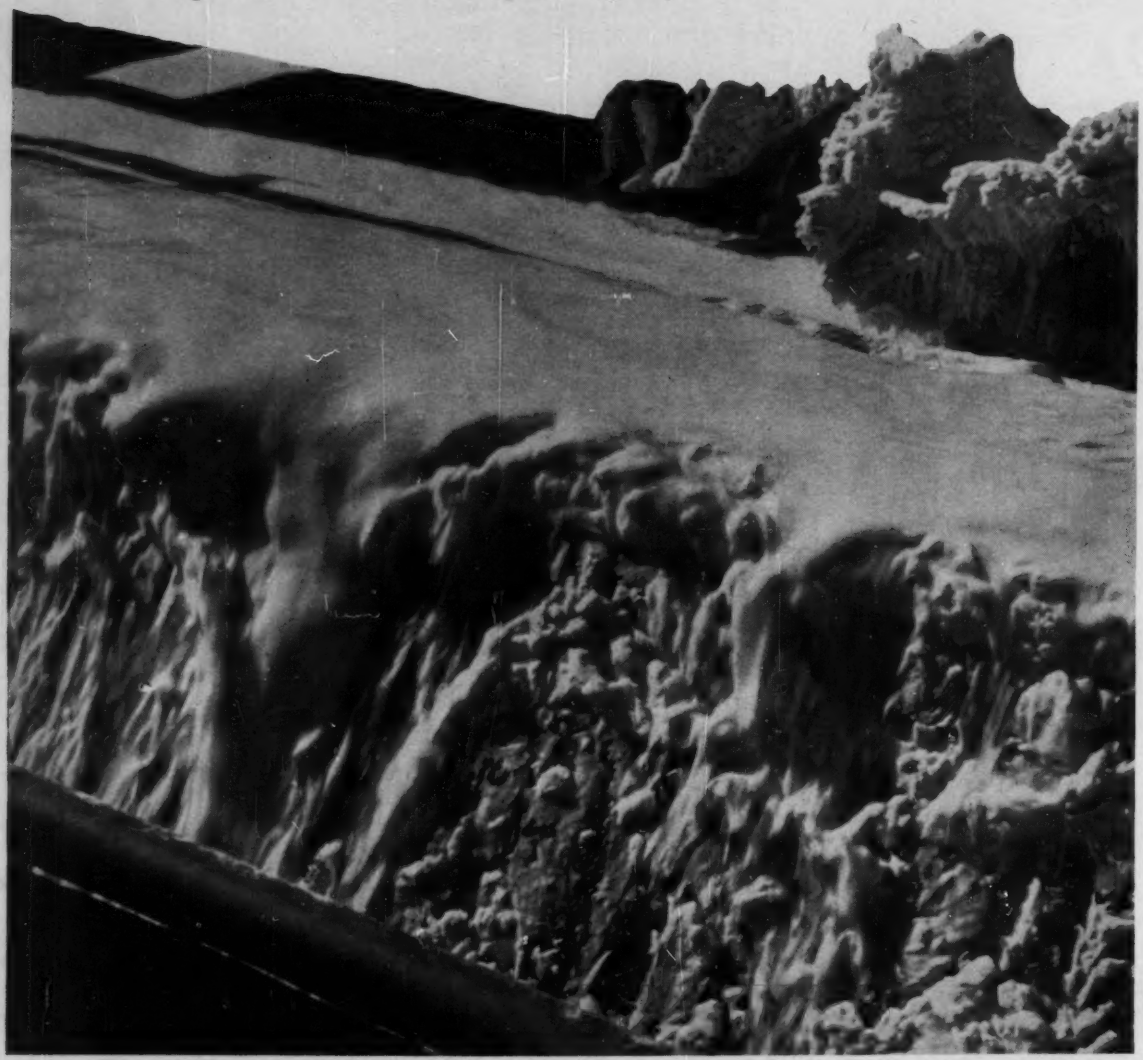
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COMPRESSORS • CONDENSERS • AIR & ELECTRIC TOOLS • TURBO BLOWERS • PUMPS • ROCK DRILLS • GAS & DIESEL ENGINES

...where soda ash shipments are geared to your changing needs...

If your requirements change (and it happens to all of us!) so that shipping dates you established yesterday do not serve your needs today, West End is geared to rearrange schedules promptly to meet your current requirements... a service we perform gladly.

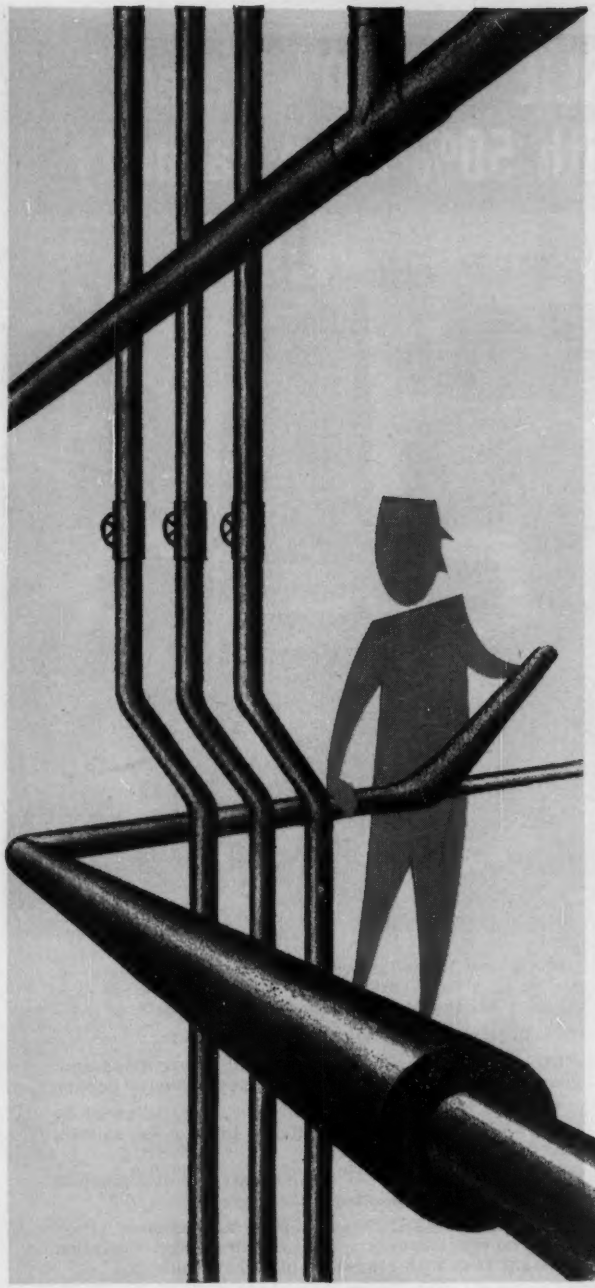


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West End Chemical Company

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EXECUTIVE OFFICES, 1956 WEBSTER, OAKLAND 12, CALIFORNIA • PLANT, WESTEND, CALIFORNIA



Flexible pipe insulation goes on fast, requires no vapor barrier finish

New Armaflex® pipe insulation stops condensation, increases efficiency of lines at 32° to 200° F. Closed cellular structure positively seals out water and vapor. Installed in one fast, easy step, Armaflex can be slipped on pipes or tubing, or slit and cemented. Flexible Armaflex follows contours of formed tubing without any cutting or fitting. It resists most solvents, oils, and corrosive chemicals and is self-extinguishing. Made 6' long, ⅜" and ½" thick, for ⅜" to 3⅛" ID tubing and pipe.

Armaflex is one of the quality products in the complete line of Armstrong Industrial Insulations. Armstrong also offers you a complete contracting service, geared to install these products economically and efficiently.

For complete information on Armaflex, send for free booklet. Booklets on other Armstrong Insulations also supplied on request. Check the ones you want on the coupon below.

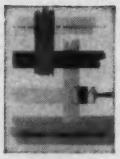
Armstrong
INDUSTRIAL INSULATIONS



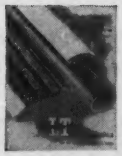
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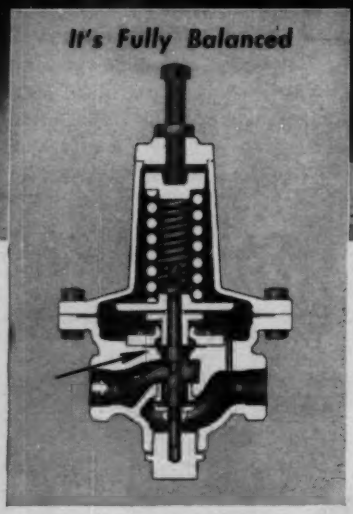
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*TRADE-MARK

Here is the new LESLIE "HI-FLO" Water Reducing Valve with 50% more capacity





Unique construction of "Hi-Flo" Reducing Valve. Note the small lower diaphragm that provides fully balanced, floating action.

HERE IS THE ALL NEW Leslie Reducing Valve with *capacity-regulation* features that have never been offered before. Here is a regulator with 50 - 100% greater capacity by actual test.*

Here's the unbeatable combination of design features:

"HI-FLO" — Large bowl construction; long stroke diaphragm gives full flow of water and other non-corrosive liquids.

FULLY BALANCED — The main valve, fully balanced by lower diaphragm, virtually floats to provide smooth, friction-free, throttling action.

DROP-TIGHT SHUTOFF — Resilient seating disc provides tight closure under all conditions.

TROUBLE-FREE DESIGN — Chatter and hammer eliminated; no piston cups or seals to clog or change. Corrosion resistant trim with renewable interchangeable fit.

Ask your Leslie Engineer to show you how the exclusive Leslie "Hi-Flo" valve can be used to your advantage in water reducing stations, fuel oil pressure control, process lines, etc. He's in your classified directory under "Valves" or "Regulators".

Write today for Bulletin 553 for graphic performance comparison and complete capacity data.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

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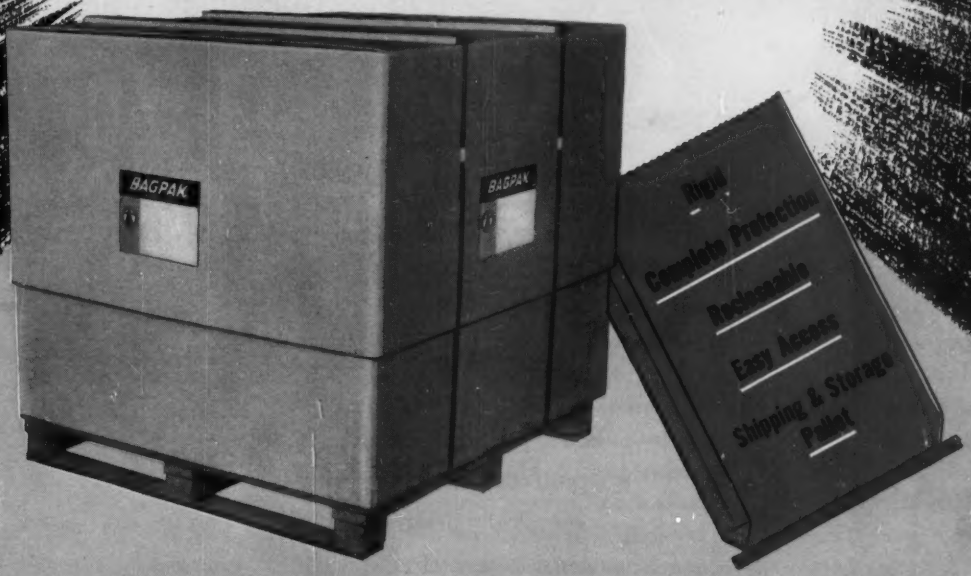
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with the NEW

BAGPAK PALLET
(Trademark)

FOR MULTIWALL BAG SHIPMENTS



After months of development and severe shipping tests International Paper Company offers a new service—the sensational, new BAGPAK (Trademark) PALLET, which gives you these advantages:—

- **NO chafed or damaged bags**
- **Bags arrive Factory-Fresh—NO distortion**
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- **Complete protection for your bags from dust or contamination**
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- **Replaceable cover feature—protects unused bags**

The new BAGPAK (Trademark) PALLET at no extra charge*

(Note* Shipping wts. 1500-1800 lbs.)

Let BAGPAK (Trademark) ship you a car of multiwalls in these new money saving BAGPAK (Trademark) PALLETS.

For details write to Dept. CE3.

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Eye Protection

For MAXIMUM, COMFORTABLE

Protection Against Chemical Splashes...

AO 484

Flexible Mask Goggle!



This goggle, one of the newer products in the AO eye protection line, has been specifically designed and engineered to protect chemical workers against splashes of acids and alkalis. Yes, and to protect them with a maximum of comfort in terms of fit, ventilation and visual efficiency! The 484 has a clear frame with your choice of a clear or green lens. Companion model No. 485, also for chemical applications, has a green frame with clear or green lens. Your nearest AO Safety Products Representative can supply you.

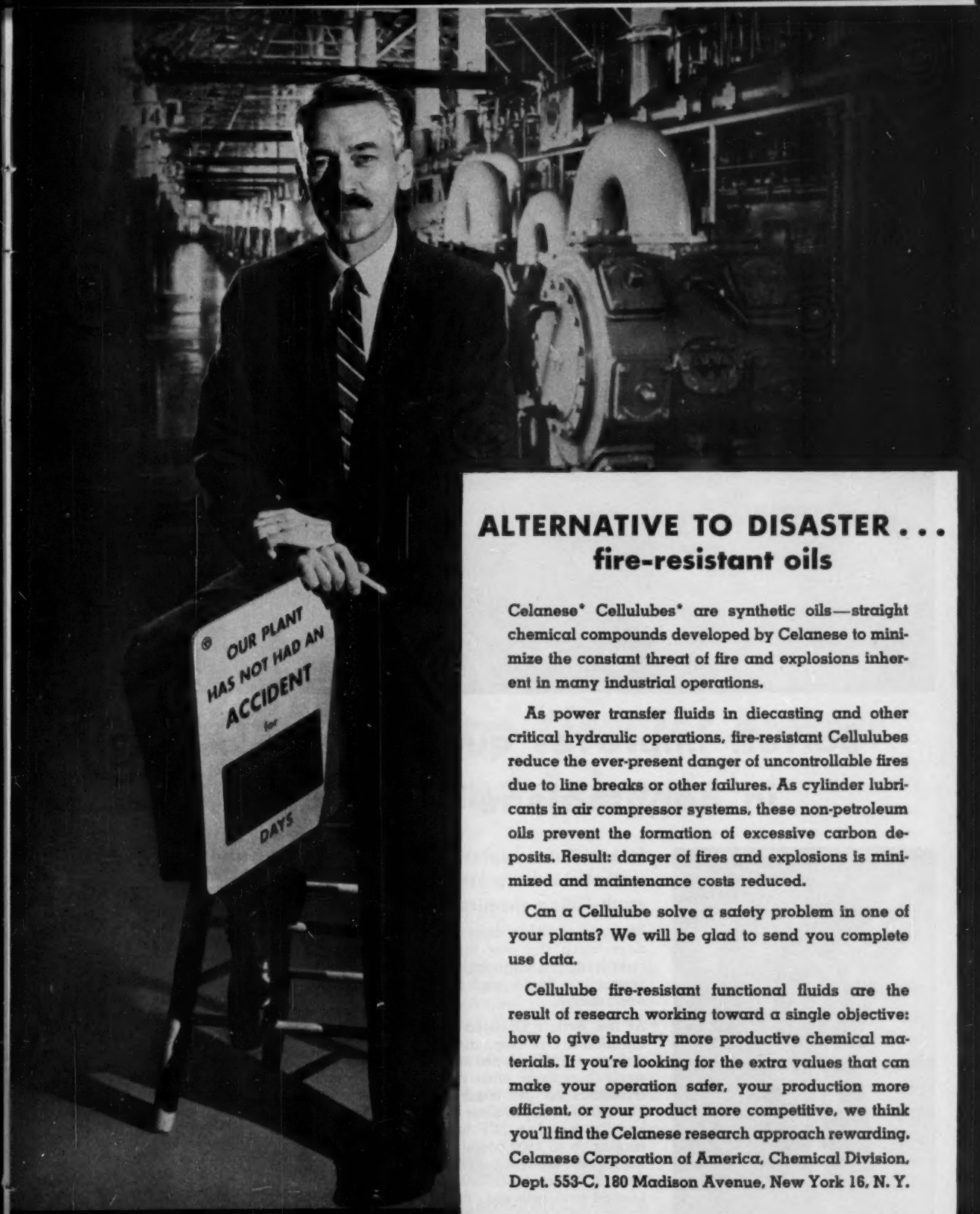
Quick Facts

- ***Lightweight*** — Fits worker's face snugly and comfortably with a cushion-like effect. Extra wide and with ample clearance — can be worn over most types of personal glasses or Safety B glasses.
- ***Ventilation*** — 4 indirect ventilation ports or grommets reduce fogging, yet hazardous chemical splashes are prevented from entering eye area.
- ***Lens*** — Interchangeable, one-piece acetate, optically correct. Offers superior resistance against acids and alkalis. Unusually wide field of vision for worker comfort, safety and efficiency.
- ***Frame*** — Soft plastic for flexibility. Solid. Fits facial contours closely.
- ***Headband*** — Plastic, easily adjustable.

Always insist on AO trademarked lenses and frames.

American Optical
SAFETY PRODUCTS DIVISION

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES



ALTERNATIVE TO DISASTER . . . fire-resistant oils

Celanese® Cellulubes® are synthetic oils—straight chemical compounds developed by Celanese to minimize the constant threat of fire and explosions inherent in many industrial operations.

As power transfer fluids in diecasting and other critical hydraulic operations, fire-resistant Cellulubes reduce the ever-present danger of uncontrollable fires due to line breaks or other failures. As cylinder lubricants in air compressor systems, these non-petroleum oils prevent the formation of excessive carbon deposits. Result: danger of fires and explosions is minimized and maintenance costs reduced.

Can a Cellulube solve a safety problem in one of your plants? We will be glad to send you complete use data.

Cellulube fire-resistant functional fluids are the result of research working toward a single objective: how to give industry more productive chemical materials. If you're looking for the extra values that can make your operation safer, your production more efficient, or your product more competitive, we think you'll find the Celanese research approach rewarding. Celanese Corporation of America, Chemical Division, Dept. 553-C, 180 Madison Avenue, New York 16, N. Y.

Basic reasons . . . . . for improved products

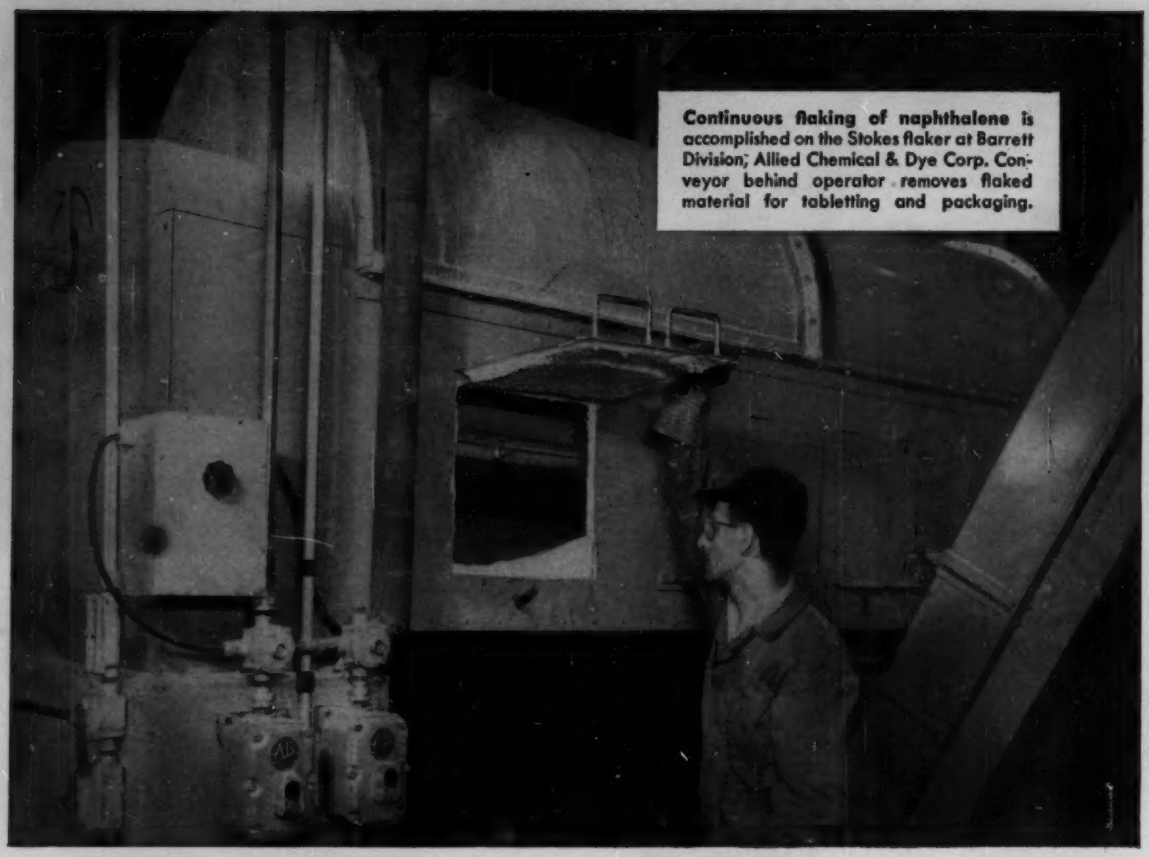
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Continuous flaking of naphthalene is accomplished on the Stokes flaker at Barrett Division, Allied Chemical & Dye Corp. Conveyor behind operator removes flaked material for tabletting and packaging.

Barrett improves quality, cuts costs in naphthalene production



Purity is higher, costs lower with continuous flaking process. Flaked naphthalene is compressed into balls or rings, with the aid of Stokes tabletting machines.

Stokes flaker replaces batch method in the processing of moth-killing chemical

Marketed in flakes, balls and handy rings which slip over the hook of coat-hangers, naphthalene is the housewife's friend—and the moth's worst enemy.

At the Barrett Division of Allied Chemical & Dye Corp., molten naphthalene at 194°F. is fed to a Stokes single drum flaker where the material crystallizes on the revolving drum. The solidified naphthalene is removed by a doctor blade at 72°F. in quantities ranging up to 1500 pounds per hour. Subsequent tabletting operations on Stokes tablet machines produce finished moth balls and rings.

Before purchasing the flaker, Barrett called on the Stokes Advisory Service and Laboratory for recommendations. Tests in the Stokes Laboratory determined the appropriate drum temperature, rotating speed and size of the unit required to give desired production. Similar tests have preceded the design of flakers for wax, insecticides, resins, many chemical intermediates and other products suited for high capacity flaking.

Stokes makes its broad experience in all phases of chemical processing available to manufacturers through this well-staffed Laboratory and Advisory Service. Full details of this laboratory and advisory service for the solution of production problems are covered in Bulletin 640.

Send for this booklet as well as an informative brochure on Stokes equipment for the Chemical & Processing Industries. F. J. Stokes Machine Company, Philadelphia 20, Pa.

STOKES



–because *Tri-Sure*® Closures protect NEVILLE Resins and Solvents

NEVILLE CHEMICAL COMPANY, of Pittsburgh, maintains a rigid standard for its big line of resins, coal tar solvents, and the new Nevsolv aromatic petroleum solvents.

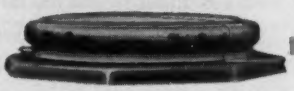
Neville's high standards start with the first step in processing these products—and they follow through to safeguarding every drum with leak-proof, tamper-proof *Tri-Sure* Closures.*

Companies like Neville—who believe that quality products should have quality *protection*—have found that Tri-Sure Closures create good-will. For the Tri-Sure *Flange, Plug* and *Seal* are accepted the world over as assurance that the exact quantity and quality put into the container is delivered.

Why compromise with the safety of *your* products—or the good-will of *your* customers? You can be *sure*—with Tri-Sure Closures. Eliminate leakage and losses—prevent tampering and pilferage—by specifying "Tri-Sure Closures" when you order drums.

Always specify **Tri-Sure** Reg. U. S. Pat. Off. **CLOSURES**

**The "Tri-Sure" Trademark is a mark of reliability backed by over 35 years serving industry. It tells your customers that genuine Tri-Sure Flanges (inserted with genuine Tri-Sure dies), Plugs and Seals have been used.*

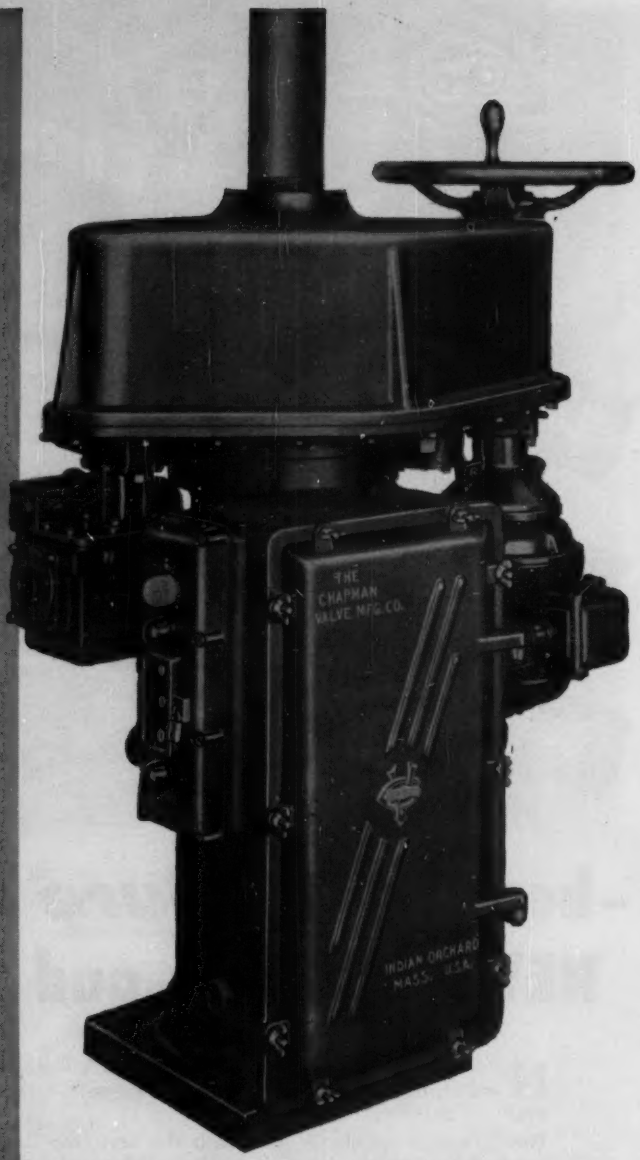
The Sign of a  Perfect Seal

AMERICAN FLANGE & MANUFACTURING CO. INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.
CHICAGO, ILL. • NILES, OHIO • LINDEN, N. J.
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Fewer Parts Mean Greater Dependability



Floorstand Motor Unit . . . control panel, motor, limit switch and push button station.



Simple, durable mechanism of Chapman's Motor Unit. Handwheel remains stationary during motor operation.

IN CHAPMAN MOTOR UNITS

Chapman's simple and rugged Motor Unit gives accurate, trouble-free control of large valves and sluice gates. It has approximately *half as many parts* as any other unit. Its simplified design, low speed motors and low-ratio, stubtooth gears combine to give positive operation without drift, in *any* position and under all conditions.

Installation is fast and simple. The floorstand unit comes completely wired, ready to connect to leads. Limit switch has micrometer adjustment for exact pre-setting for seating tightness. Motor Units operate smoothly under the most adverse conditions. All units are weather-proof and steam-tight. Write today for *new* Catalog 51.

The Chapman Valve Manufacturing Co.

INDIAN ORCHARD, MASSACHUSETTS

Who's handling public relations for you behind the Iron Curtain?

It's not an easy assignment—or the kind you'll find many people volunteering for.

But there *is* an important "public relations" job to be done behind the Iron Curtain—for you . . . for America . . . for the whole concept of freedom, free enterprise and individual rights. This job is an opportunity and a challenge as well as a serious responsibility for American business. Fortunately, with your help, there *is* an agency that can do the job—*Crusade for Freedom*, which supports Radio Free Europe and Free Europe Press.

Both these powerful, privately operated organizations continually challenge the barrage of Communist misstatements and false truths. Using saturation radio broadcasts and mass newspaper drops from message balloons, Radio Free Europe and Free Europe Press are constantly on the offensive against the Red campaign to annihilate right, reason and national pride.

Continued and heated Communist protests testify to the tremendous effectiveness of Radio Free Europe and Free Europe Press. Support freely given by free American business and private citizens will increase this effectiveness and the scope of their operations. A contribution now is perhaps the best investment you can make towards a peaceful, prosperous world.

Give generously. It's your future!

Check list for business executives in the Crusade for Freedom

- ☐ Order display material for your company bulletin board.
- ☐ Plan a paycheck stuffer to fully acquaint your employees with the importance of the Crusade for Freedom.
- ☐ Plan to conduct an in-company solicitation.
- ☐ Match employee funds with your *Truth Dollars*.

PUBLIC SERVICE ADVERTISING COUNCIL

For campaign material and information write **CRUSADE FOR FREEDOM,** 345 East 46th St., N. Y. C. 17.

METARAY® ELEMENTS

Now any infrared reflector bank can be equipped with glassless, glareless, self cleaning Metaray elements. Radiation is uniformly spread in a figure 8 pattern.

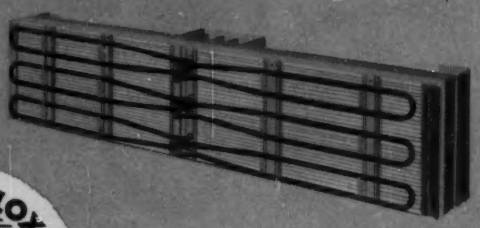
Ask for Bulletin L-1104-A



MODULAR RADIANT PANELS

A high-intensity, accelerating heat source. Four standard, modular panels completely factory assembled with built-in continuous bus, reflector, insulation, frame and mounting. Lets you tailor heat source exactly to process requirements.

Ask for Bulletin CS-606



CHROMALOX

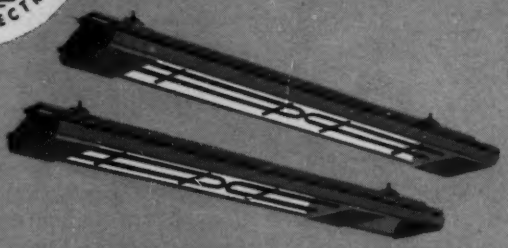
FIRST NAME IN ELECTRIC HEAT



RADIANT HEATERS

For assembly in banks. Two bolts to hold it; two wires to connect it. Six standard lengths, 14 standard wattages. Housing is rigid extruded aluminum with brightly polished parabolic non-oxidizing reflector.

Ask for Bulletin CS-604



ADJUSTABLE AREA RADIANT HEATERS

The new Chromalox URAD lets you match heat source to the work area. Choose one basic housing for your largest work. Into the housing you install any of 6 different heated lengths as your present work requires.

Ask for Bulletin CS-607

4 ways to put Far-infrared to work!

When you want reduced processing time, more uniform pre-heating, curing or pre-drying, or increased heating capacity on existing equipment, put Chromalox Far-infrared on the job! The long wavelength makes the difference.

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Contact your Chromalox representative for helpful information on Far-infrared for your application.

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Write for Literature • Manufactured only by NATIONAL CARBON COMPANY

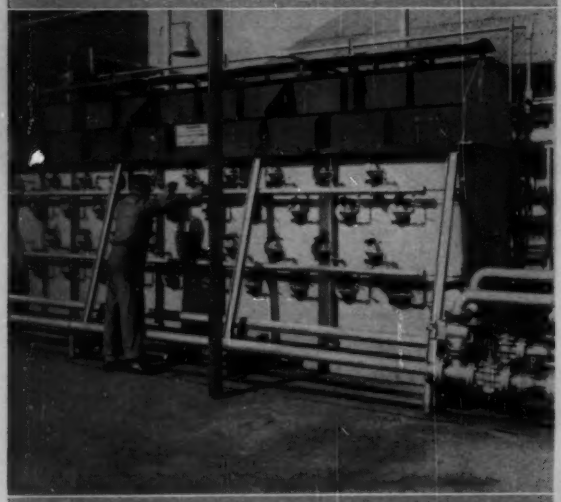
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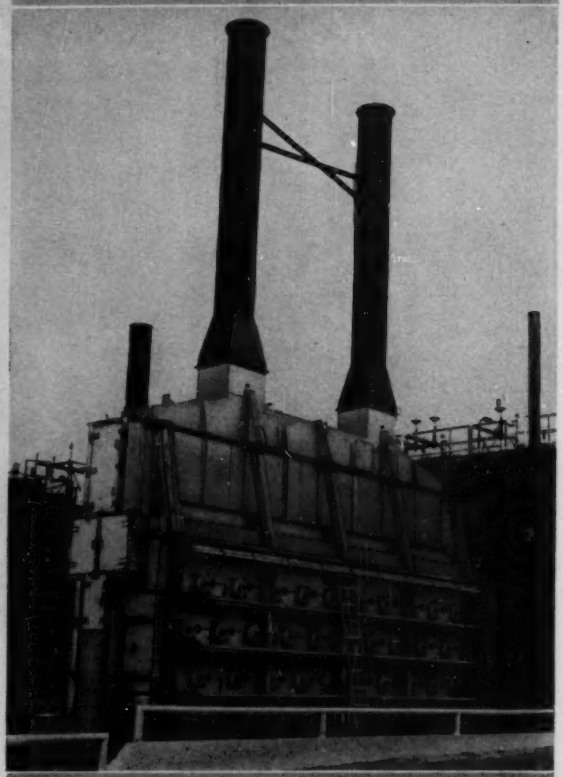


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For pilot plant or volume production . . . whether your *petroleum refining, petrochemical* or *chemical processing* operations involve critical pyrolysis reactions . . . controlled catalytic reactions in packed tubes . . . or high temperature preheating . . . you get the same benefits of Selas Zone Control:

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Selas Gradiation Heating offers new possibilities in every petroleum and chemical plant where heat processing is a precise operation.

Send for informative bulletin No. 113 "Gradiation Heating for Petroleum and Chemical Processing."

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Heat and Fluid Processing Engineers
DEVELOPMENT • DESIGN • CONSTRUCTION

After the Great Ford Foundation Gift...

What Still Remains To Be Done To Provide Decent Faculty Pay

The Ford Foundation's gift of a half billion dollars to our privately supported colleges, medical schools and hospitals, now being distributed, is magnificent. But it will be much more magnificent if it inspires completion of the job to which it gives a lift. So far as the colleges and universities are concerned, this job is primarily to rescue their faculty members from being second-class citizens economically.

Even in a period when we have become accustomed to astronomical financial figures, a half billion dollars remains an eye-popping gift. In fact, it is so imposing that a good many people who don't read the fine print are apt to conclude that it must just about solve the financial problem to which it is addressed.

Goes Only a Small Way

However, we have allowed college professors to fall so far behind the parade financially that the share of the Ford half billion dollar gift going directly to the improvement of faculty salaries ($210 million) will go only a small way financially toward doing what is necessary to provide adequate salaries.

Completion of this job for our privately supported colleges and universities calls for:

1. An increase in faculty salaries at least five times as great as that made possible by the Ford gift merely to restore salaries to their 1939 purchasing power level and an increase fifteen times as great to provide adequate salaries today.

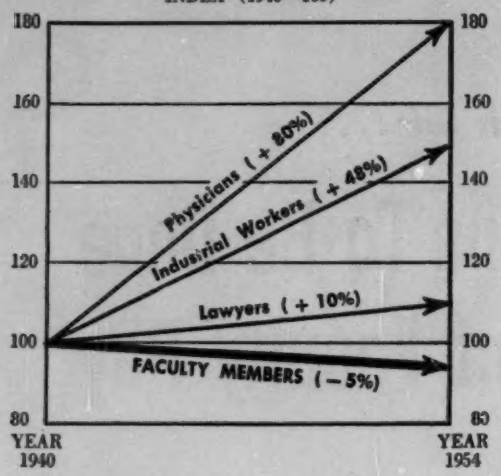
2. Some difficult and courageous decisions by the heads of the colleges and universities in apportioning the grants received by them.

Terms of Gifts to Colleges

The $210 million of the Ford Foundation gift going specifically to improve faculty salaries is being distributed on the following basis: Each of 615 privately supported, regionally accredited liberal arts and science colleges and universities receives a gift about equivalent to its last year's teaching payroll. For ten years only the income from these gifts is to be devoted to raising faculty salaries. After that all the money can be spent in any way the institutions receiving it see fit. There is no requirement that universities having other than liberal arts and science schools limit use of the gifts to improving salaries in these schools alone. They can spread it right through all their faculties if they wish.

In addition to the gift of $210 million specifically directed to increasing faculty salaries, another gift of $50 million goes to a group of 126 institutions selected for specially noteworthy leadership in improving

What's Happened to College Faculty Salaries*



* Real Income before Taxes.

Source: Council for Financial Aid to Education; U. S. Dep't of Commerce: U. S. Dep't of Labor.

the status and pay of teachers. For these schools the individual gifts add about 50% more to the amounts coming from the $210 million fund. They can be used to improve faculty salaries if the institutions choose to do so, but this is not required by the terms of these gifts.

The $210 million plus the $50 million should yield an income of $10-$13 million a year. Even if all this is used to raise salaries, it will be only a small step, however worthy, toward the $200 million per year the colleges need to meet their salary requirements adequately.

Helps Some Who Need It Most

In focussing its gift to improve faculty salaries in privately supported liberal arts and science colleges, the Ford Foundation aims at least part of the help at the spot where it is most desperately needed. Numerous surveys have indicated that the most poorly paid of all college and university faculty members are those in small, privately endowed liberal arts colleges.

But the overshadowing fact is that the teachers in our colleges and universities as a whole are badly underpaid. Just how badly is indicated by the chart above which first appeared in an earlier editorial. (Figures later than those for 1954 are not available.)

The Ford gift will turn the indicator of faculty salaries, which now lies far below the general salary trend, upward a few points. And it will do this in some places where salaries are below the wretched average shown by the chart.

But the Crucial Test Remains

College and university administrators will have the opportunity to extend further the process of getting the help provided by the Ford Foundation gifts where it is most needed. In general, this will mean giving it to senior faculty members, in order to hold experienced teachers and make college teaching attractive as a career. But to make such a division in many schools will take extraordinary fortitude.

The crucial test of the success of the enterprise of the Ford Foundation in raising faculty salaries will lie in whether it prompts the rest of us — college alumni, individuals, business firms and legislators alike — to see that it is a great beginning, not a signal for a recess.

Even with the Ford gifts providing $10-13 million a year, our privately supported colleges and universities must have an increase of about $190 million a year to provide decent faculty salaries.

This is a job far beyond the capacity of the Ford Foundation, imposing though that is. It is a job far beyond the capacities of a few hundred large corporations and a few thousand wealthy individuals. If it is to be done, it is a job at which all of us must work with a will.

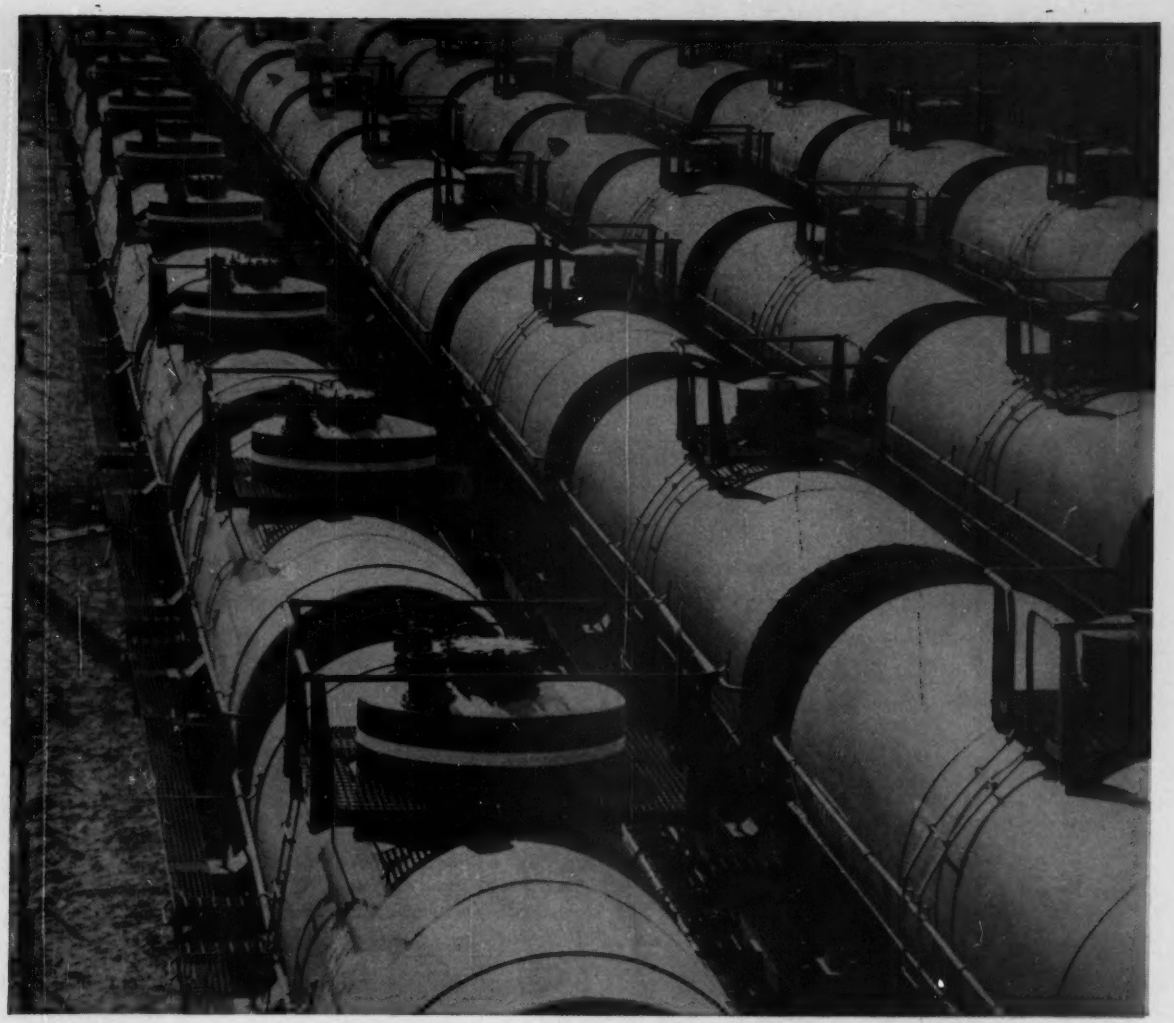
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Why not add this plant to your facilities? Our engineers will be glad to discuss your long-term bulk requirements for chemicals from National Petrochemicals Corporation.

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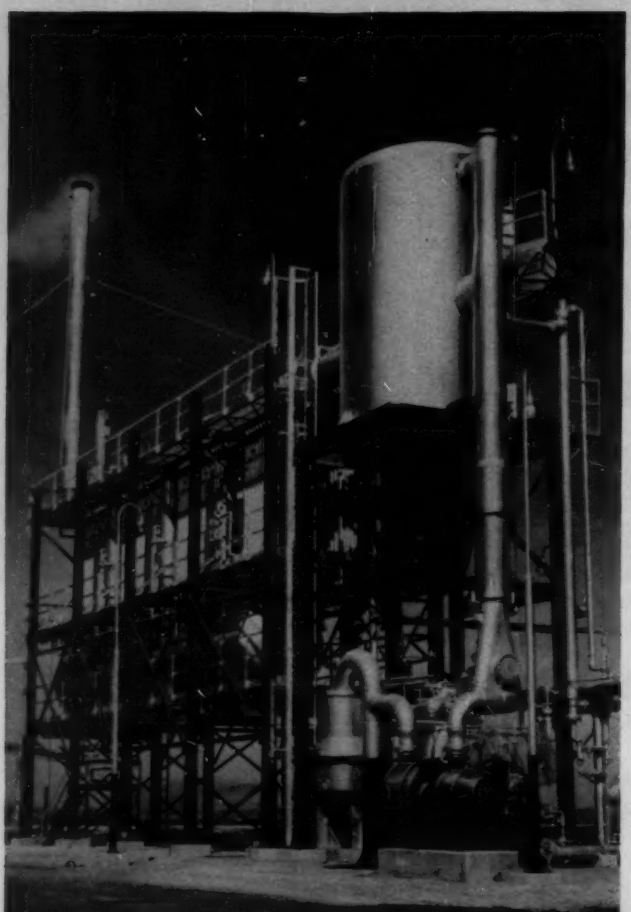
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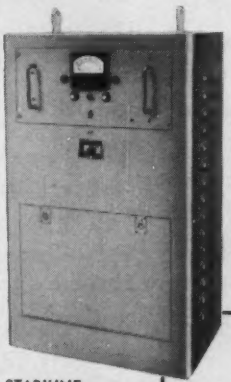


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THE SUPERIOR ELECTRIC COMPANY



A 20' long, 11'6" wide nodulizer section of a 10' x 150' Rotary Kiln ready for shipment from the Standard plant.

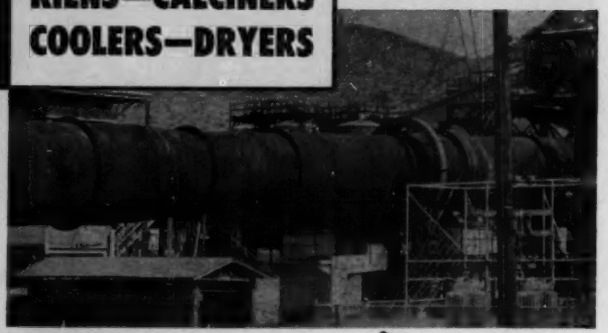
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STANDARD **KILNS—CALCINERS COOLERS—DRYERS**

The illustrations shown here give added proof of the time-tested slogan—"It Pays to STANDARD-IZE". Here is just another example of Standard's ability to produce *rugged* rotary equipment for *any* job, large or small.

From all over the country—North, East, South, West — whenever the need is for dependability—the call is for Standard. See for yourself why the list of satisfied Standard users grows every day.

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A small section of the kiln, installed and in use at a large western manganese company.



A close-up view of the same kiln. Note the solid construction. Standard Kilns are built to last.

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COMPLETE PILOT PLANT TAKES GUESSWORK OUT OF DRYING
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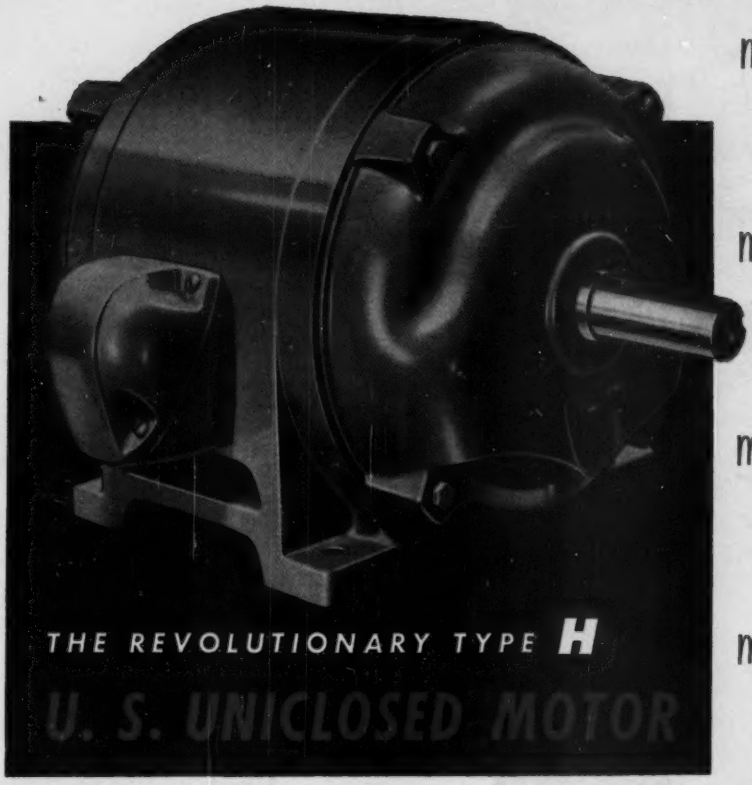


THE STANDARD FOR 52 YEARS

DS-3

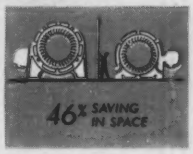
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more motor than ever before...



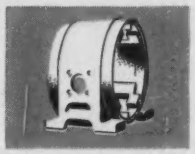
more HORSEPOWER

Type H is most compact. The same horsepower is provided in a "smaller package." An actual saving in space of 46% for the 2 h.p. size.



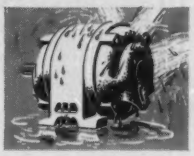
more RUGGED

The cast-iron frame defies distortion. The smooth cast-iron surface is highly corrosion-resistant. The heavy solid feet on the Type H are a substantial part of the frame.



more PROTECTION

Ventrifoil directs air, deflects water. Each end of the motor has a specially formed deflector which directs air around bearing housings and into fans on the rotor.



more INSULATION

U.S. multiple protection increases insulation life. ASBESTOS—for protection against heat. SILICONE—for moisture resistance. MYLAR—for greater physical strength.



more CONVENIENT

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New-fashioned power is the result of more and more exclusive and valuable features present only in this new motor. They include asbestos insulation to resist heat and moisture; Lubriflush bearing construction for longest life; Ventrifoil baffles to direct air and deflect water; solid cast-iron frame and normalized castings, all directed to the objectives of longer motor life and more efficient power.

A profusely illustrated multicolor bulletin fully describing construction features of the Type H motor is available. Write for your copy today.

U.S. Electrical MOTORS

MAIL COUPON NOW

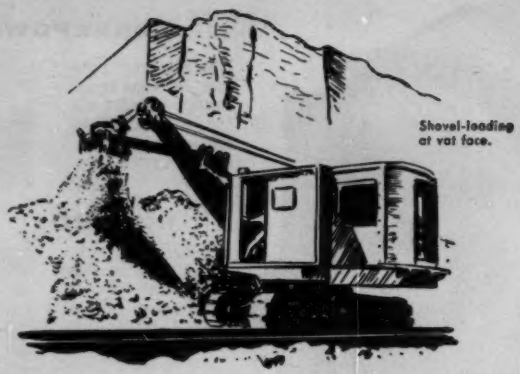
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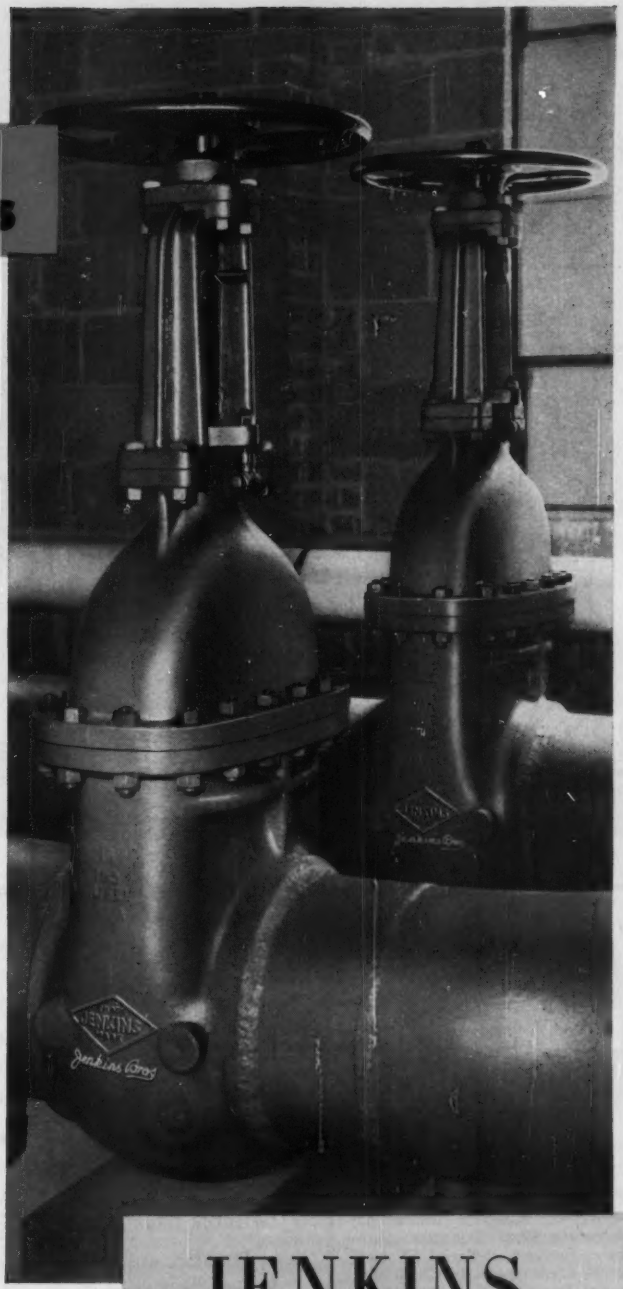
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serve the systems planned for lowest operating costs

The steadily increasing number of power generation and industrial processing installations of Jenkins Cast Steel Valves is clear evidence of economy-minded selection by valve specifiers and buyers.

Jenkins Cast Steel Valves offer any required combination of casting alloys and seating metals for any service up to 600 lbs. pressure and 1000°F. temperature. Along with specified ratings, buyers get the plus of Jenkins *extra value*, in design, in construction, in quality standards.

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Gates 2" to 24". Globes and Angles 2" to 10". Swing Checks 2" to 12". Non-return, stop and check Globes and Angles 4" to 10".
Screwed, Flanged, or Weld Ends.

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150 lb. — 300 lb. — 400 lb. — 600 lb.

PRESSURE CASTING ALLOYS

Carbon Steel (150 lb.)
Carbon Molybdenum Steel — 300, 400, 600 lb. Valves
Chromium Molybdenum Steel

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H Monel
13% Chromium Stainless Steel
Carbon Molybdenum Steel, Stellite faced
AISI Type 316 Stainless Steel

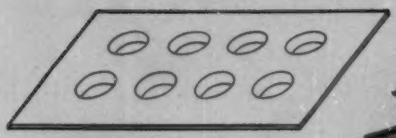
JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
SINCE 1864 TRADE JENKINS MARK
Jenkins Bros

FOR COMPLETE SPECIFICATIONS, GET THIS CAST STEEL VALVE CATALOG

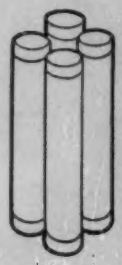
It describes all patterns, casting alloys, and seating combinations, with details of the *extra value* design and construction features. Gives pressure-temperature ratings, dimensions, and other technical data. Get a copy from your Jenkins Valve Distributor, or write: Jenkins Bros., 100 Park Ave., New York 17.



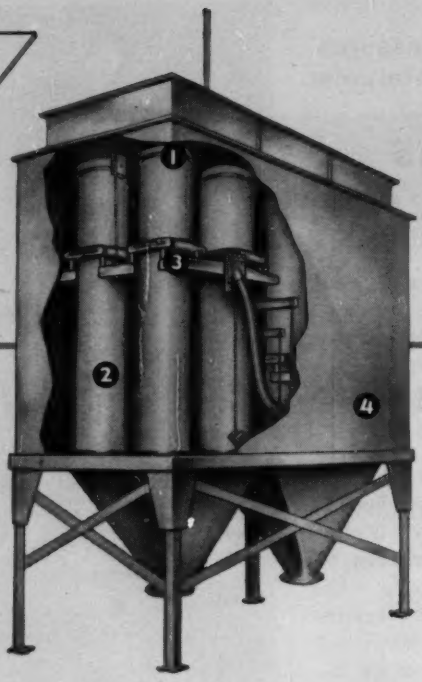
SOLD THROUGH PLUMBING-HEATING AND INDUSTRIAL DISTRIBUTORS

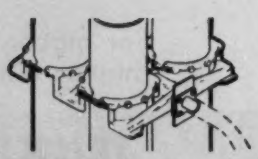


1 Air enters plenum casing at top of Series 12 Aeroturn for equal distribution to all filter bags. Bags are of felt . . . with higher filtering efficiency than woven material. Tiny pores hold even submicronsized dust particles. Cloth area is less than ⅛ that of shaker bags.

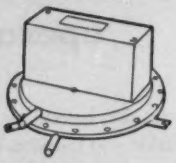


2 The air travels downward through the filter bags, assists delivery of dust into hoppers below... escapes through bag walls. Even distribution of dust puts every square inch of the filtering surface to work... avoids clogging... permits air to escape easily.





3 Self-adjusting blow rings* travel length of filter bag exterior . . . discharge reverse-air-jet into bag which blows accumulated dust off bag walls. Cleaning never interferes with filtering... which maintains peak efficiency. Aeroturn remains on the job continuously.



4 Automatic pressure switch* controls blow ring operation. Above normal pressure loss automatically actuates blow rings. When pressure loss normalizes, blow rings stop operation. Self-cleaning occurs as often or as little as needed . . . avoids over-cleaning.

Up to 75% Lower Installation Costs—99.9%+ Efficiency with KOPPERS Series 12 Aeroturn Dust Collectors!



Factory-assembled and test-operated, Koppers Model D Aeroturn Dust Collector combines features of Series 12 with unusual compactness. Capacities range from 500 to 4,800 CFM.

50% Lower Maintenance Costs . . . Up to 50% Less Space!

Aeroturn's remarkably high filtering efficiency slashes your plant and machinery maintenance costs further than can any other dust collector. Heating and cooling costs tumble because air can be recirculated . . . cleaner than outside air. Employee and community relations are improved. Yet Koppers Series 12 Aeroturn costs you less to install . . . less to maintain. Space requirements are far smaller.

Operation is continuous and automatic . . . without a drop in peak efficiency due to cleaning. Pre-fabricated Koppers Series 12 Aeroturn ranges in capacity from 1,000 to 60,000 CFM . . . contains from 4 to 64 filter bags each 12″ in diameter and up to 18′ in length.

It takes only a few minutes of your time to discover how Koppers Series 12 Aeroturn may save you thousands of dollars.

AEROTURN DUST COLLECTORS

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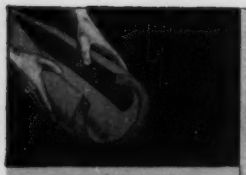
Gentlemen: Please send me a free copy of your Aeroturn booklet with descriptions, drawings and photographs. ☐ Series 12 ☐ Model D

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Company.....

Address.....

City..... Zone..... State.....

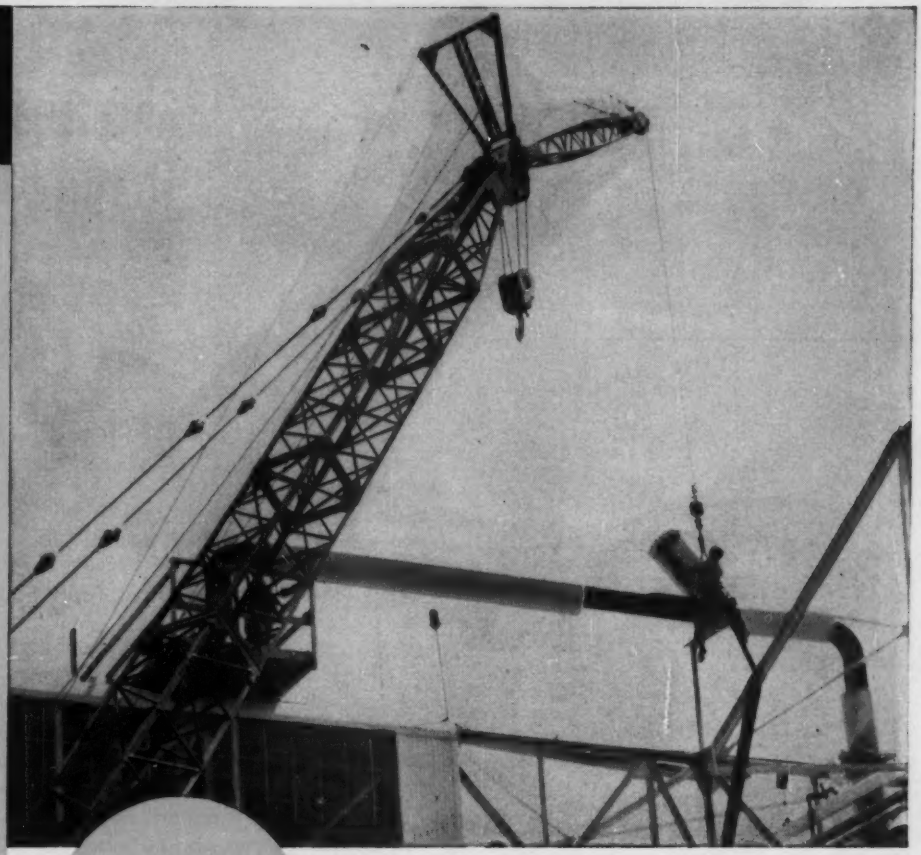


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If you can't say as much for your present pipe insulation, call your nearby Snap*On distributor whose phone number is shown in the adjoining column. He'll furnish you samples and complete technical data that will prove to you that for thermal efficiency, low-cost application, and permanence, there's nothing like G-B Snap*On. Call him today.

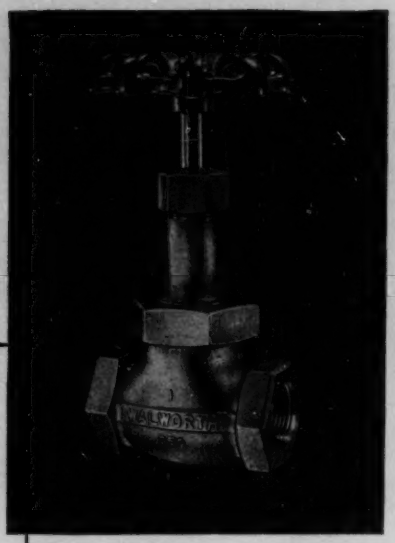
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take a good look at the Walworth "500 Brinell" no. 225P Globe



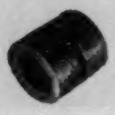
NEWLY DESIGNED HANDWHEEL: Patented air-cooled, finger-fit handwheel affords sure grip even with greasy gloves.

- the Toughest Bronze Valve Your Money Can Buy

The stainless steel, corrosion resistant seats and discs are heat treated to a hardness of 500 Brinell – hard enough to scratch glass and crush nails! The valve can be closed on sand, slag, and pipe scale without injury to the seating surfaces. "Wire drawing" is practically eliminated. All parts are accurately machined and gaged. Years of tight, positive shut-off are assured.

Available in both globe and angle types (angle type: No. 227P) in sizes ¼" to 2", this quality valve is recommended for 350 lbs. W.S.P. at 550 F, and 1000 lbs. non-shock service on cold water, oil, gas, or air.

For full data on this long-life, economical Walworth Bronze Valve, see your local Walworth distributor, or write for Circular.



IMPROVED PACKING: Molded packing of lubricated asbestos reinforced with copper wire. Suitable for practically every service. Valves can be repacked under pressure when fully opened.

note these 7 Great Features



HEXAGONAL UNION BONNET CONNECTION: Union bonnet connection eliminates any chance of distortion or leakage even though valve is repeatedly taken apart and reassembled.



OVERSIZE STEM: The high-tensile strength silicon-bronze stem assures long life and protection against wear.



SEATS AND DISCS: Plug type seats and discs of stainless steel, heat-treated to 500 Brinell hardness and machined simultaneously to a mirror-like finish, with accurate tapers assures tight positive shut-off with minimum handwheel effort.



EXTRA STRONG BODY: Made of Composition M (ASTM B61) bronze. Thick walls and rugged hexes provide a high safety factor. Valves undergo hydrostatic shell test of 1,200 psi.

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But where replacement cost is high, or where contamination through corrosion may occur, the wisest, and in the long run the most economical choice of tubing, is a stainless steel of the correct analysis for the conditions of manufacture and service.

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Six General Electric high-speed turbines operate on 'round-the-clock compressor service at Gulf refinery in Port Arthur, Texas.



For greater bucket reliability, G-E engineer locates "quiet zone" of resonant vibration in buckets to assure that steam-impact frequencies and natural bucket frequencies do not coincide.

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You buy reliability when you specify a G-E High-speed Turbine

IN PROCESS INDUSTRIES, where outages can cost upwards of $20,000 a day, turbine reliability is a major consideration when specifying compressor and blower drives. General Electric mechanical-drive turbines have built-in reliability features that can assure minimum down-time and greater profits for your operation:

HEAVY-DUTY ROTORS are machined from a single forging to withstand years of continuous high-speed operation. The rotor is completely balanced without buckets, then balanced again as each wheel is bucketed.

EXTERNAL DOVETAIL BUCKETS are attached to wheel rims with machine fit. External construction assures proper force distribution at high speed, gives better rotor protection from moisture erosion.

LARGE PRESSURE PAD BEARINGS furnished on all G-E high-speed turbines minimize shaft vibration. Generous bearing surfaces assure low unit loading for ample lubrication and minimum wear during turbine start-up.

FLANGED CONNECTIONS provide safer oil piping joints, eliminate potential fire hazards. Oil piping gages and pressure switches arranged to reduce possibility of oil spray on hot turbine parts.

CARBON PACKING used in addition to metallic labyrinth packing assures efficient steam sealing on G-E high-speed turbines. Carbon rings in external packing boxes are non-sizing, have high mechanical strength in the small sizes used.

POSITION RESTORED GOVERNING SYSTEM is designed for close accurate governing in response to load requirement and the slightest variations in steam conditions. Governor will operate with any recycle controlling system.

These are but a few of the important design features that account for consistent reliability of General Electric high-speed mechanical-drive turbines. For further information, contact your nearest G-E Apparatus Sales Office, or write for new bulletin GEA-6232, General Electric Company, Section 241-5, Fitchburg, Mass.

Progress Is Our Most Important Product

GENERAL ELECTRIC

NOW IN OPERATION–GAF'S NEW PLANT FOR HIGH PRESSURE ACETYLENE DERIVATIVES

the story behind the headline

For those of you who have not been eating, sleeping and breathing high pressure acetylene reactions as we have, a brief reminder on the background of these products may be in order. In the early 1930's, Dr. J. Walter Reppe, working in Germany, licked the previously "impossible" problem of handling acetylene efficiently and safely at high temperatures and high pressures in chemical syntheses. This led him and his group into varied investigations which resulted in the synthesis of numerous chemicals which had previously been completely unknown, or at best only obtainable by elaborate and expensive reactions.

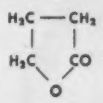
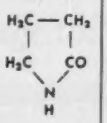
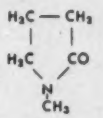
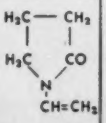
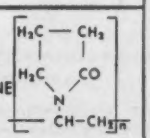
Even though widespread work in this field has continued steadily up to the present, and the laboratories of General Aniline in this country have been engaged in their own independent research for more than ten years, vast and challenging areas of research still remain for exploration in the new branch of chemistry involving high pressure acetylene reactions.

When the GAF laboratories began synthetic work in the new field, none of the products they turned out had ever been available in the U.S. in commercial volumes and at commercial prices. We, therefore, found it necessary to do some rather fancy, long-range extrapolating from the physical and chemical properties of all of the products to their potential applications and sales volumes in order to decide which would be of greatest immediate industrial value. Following these decisions came sales development, application research, and process development in the laboratory and pilot plant. Finally, the plant stage has been reached for the first group of products now to be made at GAF's new Calvert City plant.

They are a related series resulting from the reaction of acetylene with formaldehyde to yield a mixture of butynediol and propargyl alcohol. In a relatively brief time they have developed an astonishing and, we must confess, in part unexpected range of applications about which GAF's Commercial Development Department has told you in advertisements, data bulletins and personal visits. Along with the large new plant now also comes a new, full-scale sales department eager to help you use these products to your best advantage.

We expect to be reporting the commercialization of many more high pressure acetylene derivatives in the future, but no announcement will have quite the significance of this first one, both for you and for us. We believe it represents a milestone for our industry: the first of many commercial high pressure acetylene derivatives plants in the United States.

PRODUCTS TO BE AVAILABLE FROM GAF's NEW PLANT AT CALVERT CITY, KENTUCKY:

PROPARGYL ALCOHOL $HC{\equiv}CCH_2OH$	2-BUTYNE-1,4-DIOL $HOCH_2C{\equiv}CCH_2OH$
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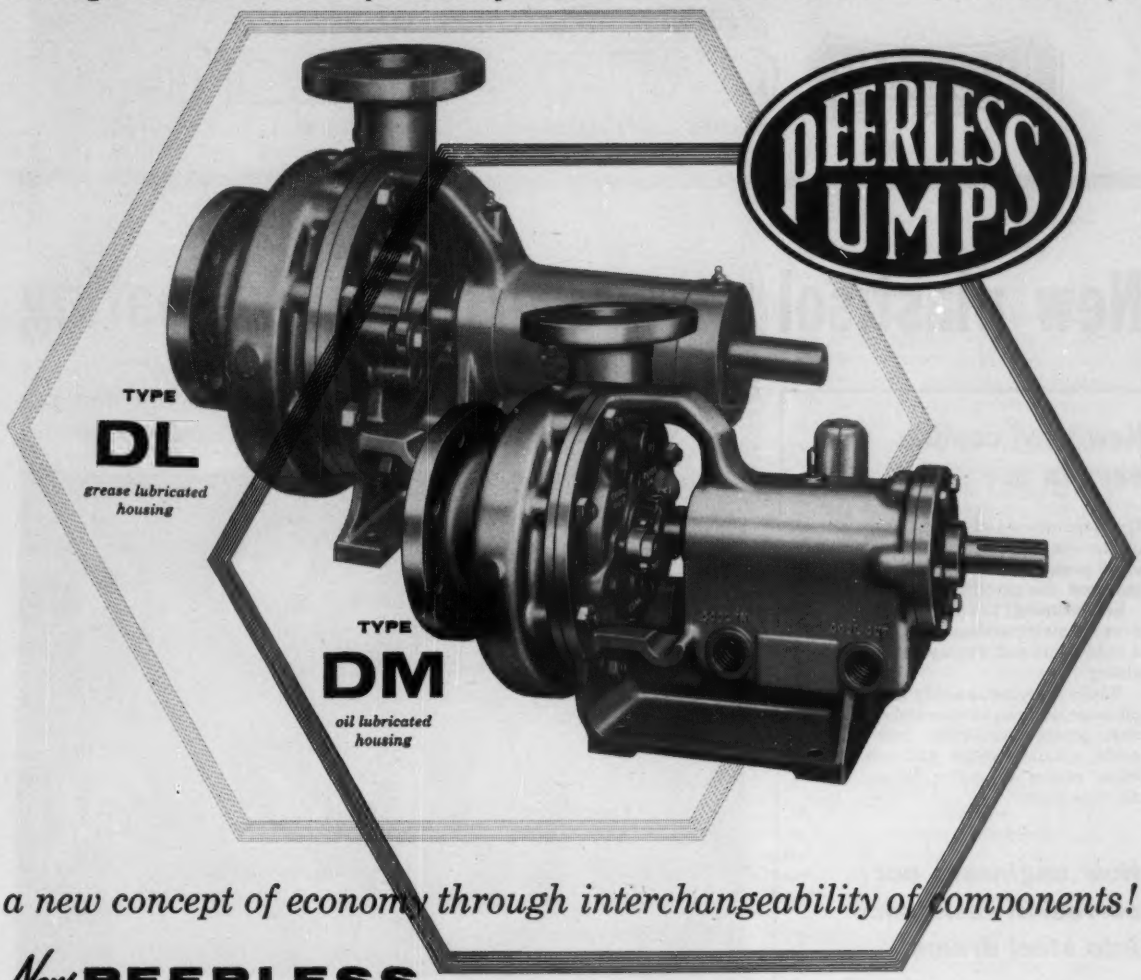
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Peerless Type DL and Type DM process pumps are available in 1″, 2″, 2½″ and 3″ sizes on an 8½″ frame and in 1″, 2″, 2½″, 3″ and 4″ sizes on a 10½″ frame. **CAPACITIES:** up to 800 gpm. **HEAD RANGE:** up to 430 feet. **DRIVES:** motor or steam turbine. **TEMPERATURE RANGE:** grease lubricated housing up to 250°F.; oil lubricated housing up to 450°F. **WORKING PRESSURES:** up to 400 psig.

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Here is
INTERCHANGEABILITY IN ACTION—

Interchangeability of component parts for DL-DM pumps is graphically shown by this slide selector. Write for your FREE copy. It shows how liquid end components are accommodated on either grease lubricated or oil lubricated bearing housings. Also provides quick reference to pump specifications and performance characteristics.

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News about

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Metallic..... Organic..... Decorative..... Protective

New plastisol sprays extra-thick coating

New vinyl coating easy to use

Development of Ucilon* 1400 now simplifies the application of a durable vinyl protective coating to walls, ceilings and the exterior of equipment.

Self-priming, this new coating goes over old paint without lifting it. It has a mild odor, and displays easy brushability.

While applying as easily as ordinary oil paint, it gives extraordinary corrosion protection. Ucilon 1400 resists acids, alkalies, water and numerous other causes of coating failure. Send for data sheet.

*Trade Mark

How engineers put corrosion resistance into steel drums

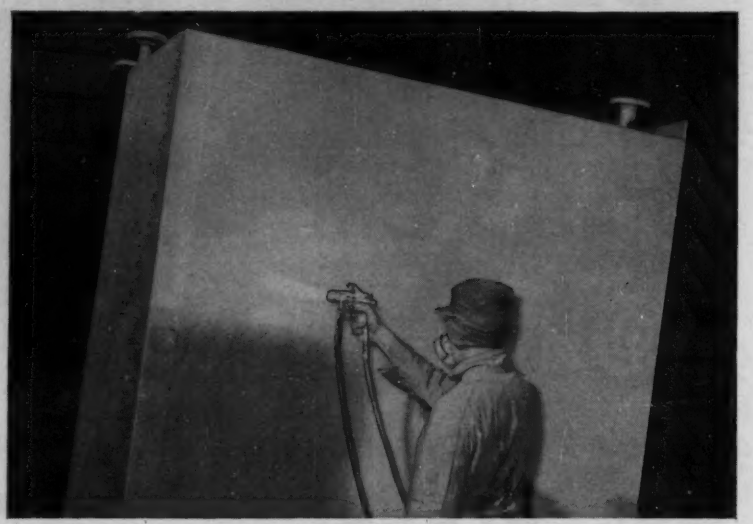
Engineers have at their command many types of chemical-resistant coatings to line drums. But which proves best for a new product? That's where a coating manufacturer comes in to help.

Unichrome drum linings include vinyl, phenolic, epoxy and plastisol formulations. These meet most needs on chemical resistance. Beyond this, they satisfy also on the impact resistance, adhesion, film continuity, distensibility and flexibility needed for the service. Engineers need only specify the requirements to have United Chromium recommend the best lining to prevent corrosion and product contamination.

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METAL & THERMIT CORPORATION

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Unichrome "Super 5300" Coating builds 60 mil film per coat . . . gives heavy duty corrosion-protection



Tank getting a heavy protective coating with Unichrome Plastisol. Large structural parts of products can likewise be durably finished.

A new and unusual plastisol formulation has been developed by United Chromium, a pioneer in this type of coating. Unichrome "Super 5300" Coating delivers the full solids content of vinyl plastisol right through a spray gun. It enables a coat 60 mils or more to be applied successfully in one application.

THICK AND TOUGH

Amounting to a vinyl "sheet" material, single or multiple coats of this new plastisol can be used to good advantage on many of the products where plastic or rubber sheets are generally specified. Super 5300 Coating also provides a durable, protective finish for large uneven surfaces where only a fluid material can be applied. Good performance is assured for two reasons. (1) With spraying, there are no seams or joints where corrosives might penetrate. (2) Vinyl plastisols have a unique combination of chemical and physical properties.

THE ADVANTAGES

Curing quickly at 350° to 365°, Unichrome Plastisols form rugged, resilient coatings with an attractive satin finish. They insulate electrically, absorb impact, don't chip or crack, resist abrasion and erosion, deaden sound.

They give extraordinary protection against a wide range of acids, alkalies, alcohols, salt solutions and moisture. With plastisol protection, ordinary metal parts and products often prove suitable for unusually severe service conditions.

For companies without adequate baking facilities, United Chromium Division can recommend nearby firms that specialize in applying Super 5300 Coating. Send for Bulletin VP-1 that tells more about plastisols.



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ELECTRONIC
MIRACLE
that increases production,
betters product quality

ULTRASONICS COMES OF AGE
. . . finally, out of the laboratory and into full scale industrial applications. Now you can use these high frequency, acoustical waves to accelerate and improve mixing, emulsifying, degassing, cleaning, plating and hundreds of similar operations. And *at the same time*, you eliminate many of the disadvantages now inherent in chemical processing such as heating, mechanical agitaton, and pressurizing by external forces.

For example, highly directional, inaudible ultrasonic waves provide much finer molecular weight distribution in resins and plastics . . . eliminate undesirable by-products. Through ultrasound, yield percentages are substantially increased . . . emulsifications are made more stable, too. In every instance savings are added and product quality is enhanced.

A NEW INDUSTRY SERVICE
Vibro-Ceramics Corporation, long the leader in developing ultrasonic transducers and associated equipment, now offers an important new group of services:

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An experienced staff analyzes your operation and makes specific recommendations.

•ULTRASONIC COMPONENTS
The requirement being determined, Vibro-Ceramics supplies the proper ultrasonic units—custom tailored to fit your present equipment.

•COMPLETE SYSTEMS
When required, Vibro-Ceramics will create, build and install a full system *(to sell or lease)* to gain ultrasonic economies throughout a series of operations.

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Vibro-Ceramics' unique combination of integrated facilities and experience is better able to define and answer your needs. To learn how ultrasonics can aid you, write to Dept. #701 for further information.

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WASTE HEAT EVAPORATORS are particularly adaptable to offshore drilling platforms, tenders and diesel barges. Practically no scale removal. Potable water is produced from the sea at zero cost because unit uses waste heat from rig's diesel engines . . . transmitting it through heat exchangers charged with sea water. Hot water flashed into a vacuum chamber is partially converted into steam, which is then condensed on cooling coils for the output of distilled water for "mud" make-up, drinking, etc. Unit above has a capacity of 300 gph — larger capacities to your specifications.

Investigate the diversified types of Cleaver-Brooks evaporators — engineered for greatest heat and power economies

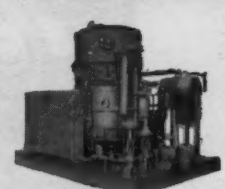
The broadened line of Cleaver-Brooks evaporation equipment now includes types for a wide variety of operating conditions — and to answer *any* need for pure potable water or high quality process water.

- Sea water, brackish water or polluted streams may be used as a prime source, thus eliminating independent pipe lines, trucking or barging.
- Distillate is uniform in quality — regardless of raw water source.
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- Stationary or mobile units operate independently and automatically after initial starting.

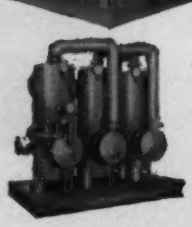
Cleaver-Brooks is highly qualified to design and fabricate evaporators (including special heat exchangers) to your specifications. For complete details, write: Cleaver-Brooks Company, Special Products Division, Dept. C, 364 W. Keefe Ave., Milwaukee 12, Wis., U.S.A., Cable Address: CLEBRO—Milwaukee—all codes.



FLASH-TYPE EVAPORATOR—Combination of four (4) 50,000 gallons-per-day evaporators with a total distilled water capacity of 200,000 gallons per day. Unit will provide entire water supply for super carrier of the U.S.S. Forrestal class. Low-pressure steam is bled from propulsion turbines.



VAPOR COMPRESSION EVAPORATOR (Model S300 DO) — Provides pure water at approximately one-half the cost of other methods. Specially suited for tankers and other bulk-cargo vessels. Distilled water capacity—300 gallons per hour.



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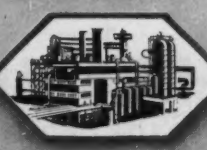
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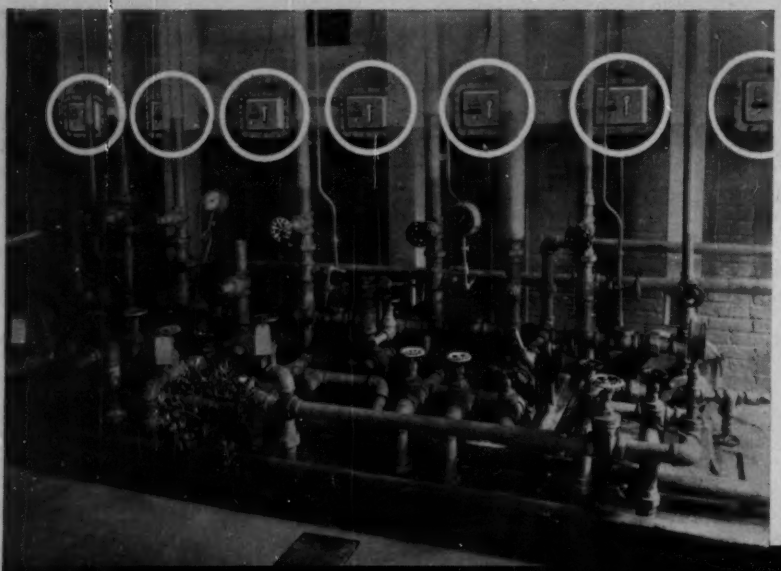
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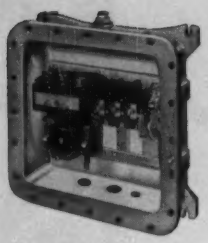
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The cover has been unbolted from this Allen-Bradley combination starter to show the wide flange construction of the explosion-proof enclosure.

Left—A row of Allen-Bradley explosion-proof combination starters operating flammable solvent pumps in a penicillin plant.

ALLEN-BRADLEY AUTOMATIC MOTOR STARTERS
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Allen-Bradley Bulletin 712 combination starters . . . which have the manual disconnect and Allen-Bradley solenoid starter in one cabinet . . . are mighty popular, today, with plant engineers, maintenance men, and electricians.

1—Allen-Bradley combination starters are SAFER than a separate disconnect switch and starter, because disconnect lever must be OFF before door can be opened. The solenoid starter is then "dead."

2—Bulletin 712 combination starters use a new visible contact disconnect switch—the latest development in safety for the operator.

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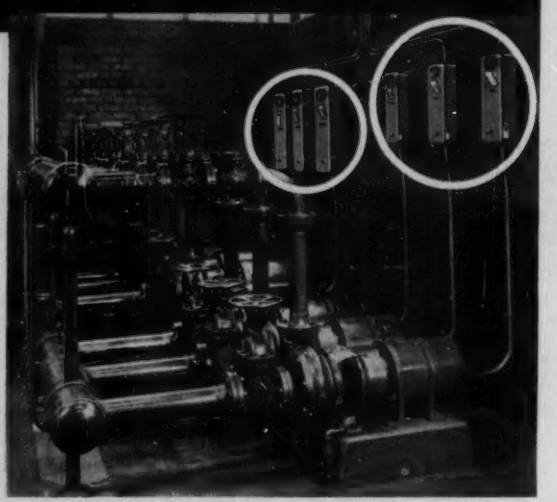
4—The double break, silver alloy contacts require no maintenance—a great advantage for starters with bolted covers.

Allen-Bradley Bulletin 712 combination starters can be supplied in several types of enclosures to satisfy any working condition.

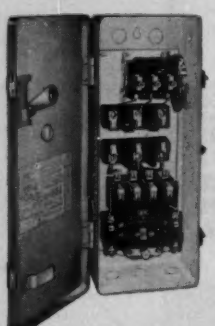
Bulletin 713 combination starters are equipped with I-T-E instantaneous trip circuit breaker in place of the manual disconnect. Send for Bulletin 712-713.

Allen-Bradley Co.
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ALLEN-BRADLEY
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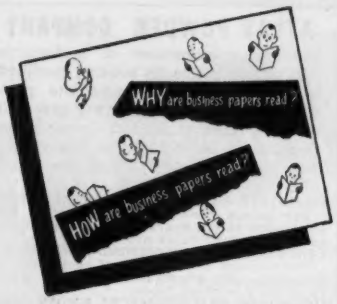
A row of Allen-Bradley Bulletin 712 combination starters for starting a battery of motor-driven pumps.



Bulletin 712 combination starter with door open to show the visible contact disconnect switch, fuse clips, and solenoid starter.

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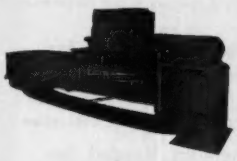


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National chemical manufacturer requires a man with experience in chemical plant operation or with refrigeration and power plant experience to assume position of Plant Superintendent after approximately one year of training. Prefer young man 25 to 35 years of age with an engineering degree; however, men with less education will be considered. Should have proven record of successful supervision and management.

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P-9248, Chemical Engineering
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This engineer will encounter problems of improvement in efficiency and increase in capacity of absorption, extraction, and distillation equipment, prescribing as necessary the modification of equipment in existing processes. Duties include: equipment specification for new processes and products; interpretation of data involving equilibria, using these data to develop equipment and to recommend operating conditions and methods of control; start-up assistance for new facilities; and trouble-shooting on operating difficulties.

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Engineers with thorough knowledge of heat exchanges, pumps, piping layouts, specification work and analysis of bids.

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PUMP DESIGNER
M. E. or equivalent with design experience in many types of pumps (vertical, horizontal process, horizontal multi-stage, etc.); will supervise drafting group.

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P-9109, Chemical Engineering
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WANTED

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330 W. 42 St., New York 36, N. Y.

Smelter Superintendent

Required for 5,500 K.V.A. electric copper smelter in Uganda, British East Africa.

Applicants should be fully experienced in copper smelter operation consisting of electric furnace, converters, etc.

Three year contract offered with married accommodation, passages, and generally good working conditions and allowances. Salary according to qualifications.

Apply with fullest details as to experience, references, personal data etc. to General Manager, Kilembe Mines Ltd., P.O. Kilembe, Uganda, British East Africa.

HEAT TRANSFER ENGINEERS SELLING OPPORTUNITIES

We require several chemical engineers for our branch offices with two or more years experience in heat exchanger design. Long established firm offers challenging opportunity to sell widely used heat transfer product whose sale involves technical ingenuity and initiative. Salaried position with incentive advantages. Must be free to relocate. Reply in confidence giving complete resume and expected salary.

P-8972, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

CHEMICAL • MECHANICAL ENGINEERS

The leading company in the field of engineering design, manufacture and construction of oxygen generators and low temperature processing plants offers junior to management positions to carefully selected engineers who desire to participate in a rapidly growing field serving metallurgical, chemical, and petroleum industries. Staff of 150 engineers and 700 workers in three factories.

Chemical Engineers

Process Design
Economic Evaluation and Estimating
Research and Development

The process and research and development engineers must have maximum strength in chemical engineering thermodynamics, fluid flow, heat and mass transfer, distillation, and physical fluid separation processes, combined with originality and creative ability for the separation of complex mixtures of low molecular weight gases by low temperature means. The research and development engineer must also be an experimentalist. The economics and cost engineer must combine many of the above qualifications with a strong interest in cost and economic factors.

Project

Chemical or mechanical engineers with major experience or interest in chemical or process equipment and plants design and construction. Practical application of thermodynamics, fluid flow, heat transfer, distillation, fluid separation processes, piping, control and instrumentation combined with strong mechanical sense and ability to coordinate a project from contract to completion.

Sales Engineer

Self energizing young engineer to participate in large scale contract negotiations with engineering and management personnel.

Highest salaries commensurate with training and experience. Profit sharing and other benefits. This is an excellent opportunity for engineers with above average ability and initiative to progress in the rapidly expanding new field of low temperature processing. Applications will be treated in strict confidence and should be complete—education—experience—interest and other information which will help us to understand and evaluate you.

Write to B. H. Van Dyke

AIR PRODUCTS INCORPORATED

P. O. Box 538 Allentown, Penna.

WANTED—CHEMICAL ENGINEER

Kentucky location of national concern has excellent permanent situation in plant engineering department for graduate chemical engineer with two years' experience or less. Must have desire for early recognition of ability and performance since position open is in direct line for possible early advancement to greater responsibility in engineering or production.

No traveling required. Attractive starting salary. Excellent benefit program.

Please submit complete resume, including details of education and experience and state starting salary required. Your reply will be held confidential.

P-8868, Chemical Engineering
520 No. Michigan Ave., Chicago 11, Ill.

CHEMICAL ENGINEER

Chemical Engineer for Research and Development position in suburban main-line Philadelphia area with 3 to 5 years experience in design, construction and operation of pilot plants in fields of ores, minerals and metals. Submit Resume.

P-9110, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

CHIEF ENGINEER

Major National and International
Manufacturers of Lead-Acid Storage Batteries

This exceptional opportunity is available to a man between 30 and 45. He will be a mature-minded, executive type individual with an E.E. or Ch.E. degree — or both — and at least five years' administrative experience as head of or assistant in a large electrochemical organization.

Duties will include administration of Battery Engineering Division, direction of product development and research and supervision of battery engineering staff. He will also be responsible for setting up quality controls, and coordination of customer engineering contacts.

ASSISTANT CHIEF ENGINEER

Another attractive position calling for executive qualifications. Applicant should have chemical engineering background with either an E.E. or Ch.E. degree—or both—plus four years' minimum experience working with storage batteries, or electrochemical or similar projects.

The man selected will have administrative duties, and will coordinate product development and research as directed by the Chief Engineer.

• • • • •

Both of these positions offer unlimited opportunities in one of the nation's largest internationally known manufacturers of batteries, and leaders in American industry for nearly a half century. The salaries are commensurate with these high-level positions.

REPLY TO

P-9315, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

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BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

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The advertising rate is $16.95 per inch, (effective Jan. '56) for all advertising appearing on other than a contract basis. Contract rates quoted on request.

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EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

Send NEW ADVERTISEMENTS to N. Y. Office, 330 W. 42nd St., N. Y. for April issue closing March 30th.

PRACTICALLY NEW
HEAT EXCHANGERS
SHORT TIME USE ONLY
ALL ARE MODERN FLOATING HEAD DESIGNED

11—670 sq. ft. ROSS #1920, 1 shell pass, 2 tube passes, steel shell; 29" x 22', 125 PSI WP @ 250°F. Admiralty brass tubes; 1" OD x #18 BWG x 20', 125 PSI WP @ 200°F.

13—1257 sq. ft. ROSS #2520, 1 shell pass, 2 tube passes, steel shell; 26" x 23' 7", 125 PSI @ 250°F. Admiralty brass tubes; 1" OD x #18 BWG x 20', 50 PSI WP @ 200°F.

6—1280 sq. ft. GRISCOLM-RUSSELL, Style FST, size 25-8-240, 1 shell pass, 2 tube passes, steel shell; 26" x 22'7", 125 PSI WP • 300°F. Admiralty brass tubes; 1" OD #18 BWG x 20', 125 PSI WP • 200°F.

12—1320 sq. ft. ALCO, type C1-32-44-H, Size 27-102, 1 shell pass, 2 tube passes, steel shell; 26", x 10'3", 125 PSI WP @ 150°F. Admiralty brass tubes; 1" OD x #16 BWG x 16', 125 PSI WP @ 150°F.

36—3400 sq. ft. WHITLOCK, 1 shell pass, 2 tube passes, steel shell, 34" x 23'8", 125 PSI WP. Admiralty brass tubes; 1" OD x 18 BWG x 20', 150 PSI WP.

Complete Specs and Prints Upon Request

EASTERN SCRAP & SALVAGE CORPORATION
65 MUIRHEAD AVENUE, TRENTON, N. J. OWEN 5-6351

MARCH SPECIALS

New Sturtevant #7 Rotary Blender SS 15 HP exp. pr. mtr, dustproof
Day 5 gal. S/S Jacketed, Vacuum Mixer
Bird 40" rubber covered Cent. 40 HP mtr.
Buflovac 500 gal. Iron Reactor, jktd & agtd.
Lee 500 gal 316 S/S Jktd. Still, complete
13,500 gal. 347 SS Tank, 10½x21'8"x¼"
Raymond #40 SS Imp Mill, 40 HP motor
Gen. American 42" x 120" twin drum dryer
Baker Perkins size 30, type RWUEM jktd Mixer, SS, with 150 HP motor, sigma arms, "NEW—NEVER—USED".

NEW—Steel & S/S Mixers, Kettles, & Tanks. Fabricated to your Specifications. Engineering Advice Available.

WE BUY COMPLETE PLANTS OR SINGLE UNITS.
WHAT HAVE YOU FOR SALE OR TRADE?

YOU CAN BANK ON EQUIPMENT CLEARING HOUSE, INC.
111 33rd Street Brooklyn, N. Y.
SOuth 8-4451—8782—4452

SWEETLAND FILTER

No. 7 Sweetland Filter, 280 sq. ft. area approx.; 41 leaves on 2" centers; just replaced with another larger type filter with separate slurry feeder of the open type, and agitator; complete unit first class condition, and can be inspected and shipped immediately from Chicago.

FS-9035, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

WANTED
KILN OR COOLER
8' x 80'
OR LARGER

Producers Supply & Engineering Co.
4200 S. Lawndale Avenue
Lyons, Ill. *Phone:* Lyons 3-4526

WANTED—SURPLUS
Chemicals—Dyes—Drugs
Colors—Pigments—Oils—Waxes
By-Products—Wastes—Equipment

CHEMICAL SERVICE CORP.
80-04 Beaver St. New York 5, NY

WE NEED
All Kinds of Oil Refinery and Chemical Equipment, also Tanks
Write — Wire — Phone
Weinstein Co., Div. of Surplus & Salvage Co., Inc.
910 West 8th Street Jamestown, New York

B & W BOILERS

In closed food plant in Chicago, we have two Babcock & Wilcox, 600 HP, Sterling type boilers, Class 50, new 1940 and 1950; 200 psi, with automatic stokers, hoppers, water filtration, miscell. pumps, motors, etc.; recently passed insurance and local inspection; first class condition, inspection invited; can be purchased individually or as complete unit.

FS-9032, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

WANTED

Baker Perkins vacuum type, jacketed intensive mixer. 100-150 gallon working capacity, Sigma blade, tilt discharge. State model #, serial # and H.P. rating in your reply.

W-8364, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

— WANTED —
SURPLUS LOTS
VALVES & PIPE FITTINGS
Unused—Any Type—Any Quantity

PRUDENTIAL PLUMBING PRODUCTS

Foot of Centre Street Newark 2, N. J. MArket 4-2277

CUSTOM REFINING FACILITIES . . .

AVAILABLE
- Complete Distillation Service • Distillations
- Extractions • Fractionations

WANTED
- Drum Lots—Tank Cars
- All Types of Crude Mixtures
- By-Products, Residues, Wastes
- Contaminated Solvents

Truland CHEMICAL & ENGINEERING CO., Inc.
Box 426, Union, N. J. MUrdock 6-5252

SEE OUR STOCK

CENTRIFUGALS

1—AT&M Susp. 48" dia. Perf. Basket, St. St., Fume tight
1—Fletcher Susp. 40" dia. Imperf. Basket, Steel
1—Tolhurst Susp. 26" dia. Imperf. Basket, Steel
1—Bird 36" x 50" Solid Bowl, Steel
1—Bird 24" x 24" Horiz. Steel
6—DeLaval Nos. 74-11; 94-01; 600, LA-11

CONDENSERS—EXCHANGERS

10—St. St., Shell & Tube—to 900 sq. ft.
4—St. St. Coil type—40 & 55 sq. ft.
8—Steel, Shell & Tube—785, 446, 335 sq. ft.
60—Copper—from 37 to 3000 sq. ft.

DRYERS

4—Devine #27 Vacuum Shelf Dryers, 475 sq. ft.
2—Devine #23 Vacuum Shelf Dryers, 365 sq. ft.
3—Devine Vacuum Shelf Dryers, size 17, 80 sq. ft. UNUSED
1—Bowen 5' dia. Stainless Steel Spray Dryer
1—Bowen St. St. Lab. Spray Dryer
1—Stokes 3' dia. x 15' long Jacketed Rotary Vacuum Dryer
6—Double Drum Dryers: 42" x 120"; 24" x 60"; 24" x 36"; 22" x 38"
3—Rotary Hot Air Dryers or Kilns: 5' x 30', 4'6" x 40', 3' x 24'
3—Rotary Furnace Tubes 24" D x 8'6" L—Chrome nickel Alloy
1—Hardinge XC-2 Ruggles Coles Rotary Steam Tube Dryer, 4' D x 30' L
2—Davenport Rotary Steam Tube Dryers, 6' dia. x 40' long
2—Davenport size 2A Dewatering Presses

EVAPORATORS—STILLS

1—Goslin-Birmingham 6775 sq. ft. Quadruple Effect, Vertical Long copper tubes
1—Conkey 1900 sq. ft. Triple Effect, Vertical long Herculoy tubes
1—Buflovak 588 sq. ft. Double Effect, all stainless steel
1—Stainless Steel, 145 sq. ft. coil, 500 gal.
1—Stokes 150 gal. St. St. Jacketed Vacuum Still
2—Aluminum Bubble Cap Columns 36" dia. x 45 plate
3—Stainless Steel Packed Columns: 8" dia. x 26' H; 14" dia. x 25'; 23" x 80"
2—Stainless Steel Cascade Columns 5' dia. x 50' high

KETTLES

3—Bartlett-Snow 6' dia. x 3' deep Jacketed Stainless Steel Mixing Kettles
4—St. St. closed—to 450 gal.
35—St. St. open top—to 550 gal.
5—Aluminum, closed, 35 to 250 gal.
2—Horiz. Steel, Vacuum or Pressure Cookers, Agitated, 5000 gal. & 8500 gal.

AUTOCLAVES

2—Blaw Knox ½ gal. St. St. agit. 2000# Pr.
3—St. St. T347, 13 gal., 1400# test, 50# jkt.

FILTERS

3—Sweetland Filters: #12 (72 lvs.); #5 (20 lvs.); #2 (18 lvs.)
2—Oliver 5'3" dia. x 8' F Continuous Panel Type Filters, gas tight hoods and re-pulpers—UNUSED
1—Swenson 8' x 8' Rotary Vacuum Filter, Precoat type. Acid proof construction
5—Cast Iron Filter Presses, 30" x 30" open delivery, 28, 35, and 50 chambers
4—Filter Presses, closed delivery, 12" to 36"
1—Niagara #110-20 St. St. Pressure Filter, 110 sq. ft.

MILLS

1—Patt. Fdy "DJ" Unlined Jacketed Steel Ball Mill, 6' dia. x 8' long—UNUSED
4—Pebble Mills 6' D x 8' L, 45" x 42"
1—Al. Ch. 6' D x 16' L Steel Lined Contin. Ball Mill
3—4'6" D x 12' L contin. Pebble Mills
1—Hardinge 6' D x 22" L Conical Ball Mill, Steel Liner
1—Charlotte #50 Colloid Mill, 75 HP
1—Penna Ring Type Granulator, Trojan K3-24, 40 HP
3—Fitz. Mill St. St., F-8, K & D
5—Hammer Mills: Jeffrey 42 x 36; Gruendler 36 x 24; Jay Bee 75 HP; Williams 14" x 14"; Williams size A, St. St. and Aluminum
1—Sturtevant 8 x 10 Jaw Crusher
3—Attrition Mills, 30", 24" & 16"
1—Pug Mill, St. St., two 7" dia. overlapping chambers 3'9" L. Jktd.
3—Mikro Pulverizers #2-DH, 2-TH, 3-TH

MIXERS—BLENDERS

3—Readco Heavy Duty Double Arm Sigma Blade Jacketed Mixers 50 gal. work. cap. 30 HP Expl. Pr. Motor. Built 1951-53
4—Sprout Waldron size 12 Ribbon Mixers, 336 cu. ft. work cap.
2—W & P Sigma Blade Double Arm Jacketed Mixers, 100 gal. work cap.
1—Patt. Kelly St. St. Twin Shell Blender, 5 cu. ft. work. cap.
9—Side Entering Stainless Stele Mixers, 7½ HP, 10 HP, 15 HP & 25 HP
4—Falk Vertical Agitator Drives #10, 10:1, 300 HP—UNUSED
10—Turbo Vertical Drives, #5B, 5:1, 40 HP

JUST PURCHASED

1—Stainless Steel Spray Dryer, 19' dia. x 20' high, with Western Precip. nozzles, fans, oil burner etc.

4—Swensen Walker Crystallizers, steel, jacketed, each 30' long.

TANKS

12—Aluminum, 3000 gal., 5 compart.
10—Aluminum, 500 gal., 80# WP.
1—Monel, 450 gal., coils; ¼"
1—St. St., T304, ⅛" 10,500 gal. Horiz.—UNUSED
1—St. Clad, T304, ⅜", 6500 gal. Vert.
1—St. St. T316, 5/16", 4000 gal. Hor.
10—St. St. Pressure Tanks—to 4000 gal.
20—St. St. Storage Tanks—to 1000 gal.

HQ FOR STAINLESS STEEL EQUIPMENT

USED EQUIPMENT IN STOCK—Tanks, Kettles, Receivers, Exchangers and Condensers, Stills, Agitators, etc.

NEW TANKS IN STOCK—From 30 gal. to 10,500 gal. sizes. Also large stock of prefabricated tank sections and heads to assure quick delivery of tanks.

CONVERTING EXISTING EQUIPMENT—(Your own equipment or our stock)—Can be done in our own shops utilizing surplus new or used materials on hand. HELIARC WELDING—Water quenched stabilized welds.

Equipment Bought & Sold

Plants Liquidated

PERRY EQUIPMENT CORP.

Phone ST evenson 4-7210

Cable—PERI

1413-21 N. 6TH ST. PHILADELPHIA 22, PA.

Late Type Rebuilt Equipment UNION

Rebuilt Machinery Established 1912

For Immediate Delivery — Great Savings

MIXERS

850 gal. Jacketed Mixing Tanks.
Day 35 to 75 gal. S. J. Imperial Double Arm Mixers.
Day 650 gal. Jumbo S. J. Mixer.
Stokes, Day, New Era, Hottman Mixers, from 2 to 450 gal., with and without Jackets, Single, Double Arm Agitators.
Baker Perkins, Day, Readco Heavy Duty, 2 to 160 gals., Double Arm Jacketed Mixers with Sigma or Fish Tail Blades.
Gemco 56 cu. ft. Double Cone Blender.
J. H. Day 50 gal. Imperial S. S. Jacketed Double Arm Mixer.
Day, Robinson, Bailey, 15 to 10,000 lbs., Dry Powder Mixers.

LABELERS

Models D and NA4 Knapp Wraparound Labelers.
Resina LC and Elgin Cappers.
Burt Wraparound Labeler, to gal.
Pony M, MX, ML, World, Ermold, Pneumatic Semi and Automatic Labelers.
Capem 4-Head Automatic Labeler.

FILLERS

Horix and Elgin Rotary Fillers.
S. & S. G1, G2, G6, HG88 Fillers.
MRM S. A. Stainless Steel Vacuum Fillers.
Triangle Elec-Tri-Pak Fillers, all sizes.
Elgin 5-Head, Hope 1, Filler 2 and 4-Head Stainless Steel Piston Fillers.

PACKAGING MACHINES

Standard Knapp 429 Carton Sealers.
Pneumatic Scale Packaging Units with high speed Carton Feeders and Bottom Sealers, Weighers, Top Sealers with Compression Drying Units, Carton Liners, interconnecting conveyors.
Palmer Box Forming Machine.
ABC Automatic Carton Sealer.
Miller, Hayssen, Package Machinery, Oliver, Campbell, Transwrap Wrappers.
Stokes and Smith Model B Transwrap with Auger Feed and Fin Seal Attachment.

GRINDING MILLS—SIFTERS

Mikro 3TH Pulverizers with 30 HP motors.
Mikro 2TH, 1SH and Bantam Pulverizers: Schutz-O'Neill Mills.
Charlotte #3 Monel Colloid Mill.
Eppenbach V9 Aloxite Colloid Mill.
Day, Robinson, Tyler Hum-mer, Great Western, Gayco, Raymond Sifters.
Rotex Sifters—40½" x 120" and 40" x 84".

MISCELLANEOUS

Podbelniak 6080 S. S. Solvent Extractor.
Oliver, Sweetland #2, Sparkler, Sperry, Shriver, Alsop Filters.

OVER 5,000 MACHINES IN STOCK—INSPECTION INVITED
Complete Details and Quotations Available—Write Today!

UNION STANDARD EQUIPMENT CO.
318-322 Lafayette Street New York 12, N. Y.

TOP PRICES PAID FOR YOUR SURPLUS EQUIPMENT

NEW AND GOOD - AS - NEW EQUIPMENT

1—Stainless Tank #430 Chrome. vert. 7'x10' deep.
20—Jacketed Kettles—Stainless, Copper, Aluminum.
1—Day Mixer, steam jacketed, 50 gal. Sigma Blade.
1—Copper Evaporator, steam jacketed, 9'1"x3'9".
60—New Pressure Cookers, 18"x18" & 24"x28".
150—Pumps—steam and electric.
1—New Glass Nash Centrifugal Pump, 160 gpm.
1—New Nash Vacuum Pump Type AL-572.
1—Buflovak Jacketed Impregnating Tank 42"x52".
1—4x8 Sturtevant Jaw Crusher.
1—Abbe Ball Mill, 30"x42" Buhrstone lined.
#316 Stainless Steel Tanks, new 100, 200 & 360 gal.
1—Nash Air Compressor, Type AL-623.
1—Manton Gaulin Stainless Homogenizer 125 gph.
1—I&R Vacuum Pump, 5 H.P., 60'.
4—Heat Exchangers, 12" dia. 11' lg., 43 steel tubes.
1—Stokes Single Punch Tablet Machine.
1—Raymond 8" Hammer Mill, like new.
Davenport Rotary Steam Tube Dryer, 6'x36'.
2—Stainless Steel Steam Jacketed Readco Mixers.
1—#316 Stainless Reactor, 265 gals. cap., jacketed.
Abbe Pebble & Tube Mill, 5'x22'—Buhrstone Lined.
1—Patterson Ball Mill, porcelain lined, 17"x27".
1—Patterson Ball Mill, 42x36, jacketed.
45—Steel Tanks from 100 to 100,000 gals.
2—Large Steam jacketed Horizontal Mixers.
Robinson Pulverizer #20, with 2 motors 10 HP each.
Robinson Ribbon Type Mixer, 30"x10'—like new.
4—Horizontal Retorts 200# w.p., A.S.M.E. from 12" to 24" dia., 4' to 12' long.
2—Crystallizers—10' long.
3—3,000 gal. jacketed Kettles with Turbo Agitators.
1—#10 Day 300 gal. jacketed Sigma Blade Mixer.
1—Sparkler Stainless Filter Model 18-S-23.
1—Sparkler Stainless Filter Model 33-S-9.
3—2500 gal. Pfaudler G/L Tanks & S/S Agitators.
6—Blackburn-Smith Jacketed Filters, 20 to 160 gpm.
1—Jeffrey Vibrating Conveyor, 15' long.
4—Hoffman Steam Jacketed Filters.
1—Meade Mill #2 with 7½ H.P. Motor.

H. LOEB & SON 4643 LANCASTER AVE., PHILADELPHIA 31, PA.

WATER FILTERS

Still erected in food plant in Chicago, two used Niagara diatomaceous earth water filters, capacity 300-400 gpm each, with 15 Niagara leaves, total area 330 sq. ft. in each filter (can be increased by 1/3), quick-opening cover, 5" manifold, complete pumps and accessories, would cost new today $15,000. or more; our price half of new; inspection invited.

FS-9028, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

FILTERS

1—Celluio Model F-66 filter, bronze construction, for syrups, etc., capacity approx. 5 GPM, with transfer pump, 110 volt, AC motor; complete unit; 1—Ertel Model WE 12-disc filter, same as above, capacity 10 GPM, complete with pump and accessories; reconditioned and guaranteed; inquiries invited.

FS-9034, Chemical Engineering
330 W. 42 St., New York 36, N. Y.

LOOK

RIGHT PRICE—FAST DELIVERY—GUARANTEED

MUST MOVE IN 30 DAYS UNBELIEVABLE SAVINGS
2—UNUSED No. 12 Sweetland Filters, 48 bronze monel covered lvs. 3" cc.

2—8'x12' Rotary Kilns.
3—6'6"x50' D. H. Rot. Dryers, ⅝".
1—#2 Simpson Mixer, motor drive.
2—54"x70" and 1—40"x60" Bird Continuous Centrifugals, S/S Solid bowls.
2—8/5 Hersey Rotary Dryers, 5x26' and 6'x23'.
1—#502-16 Link Belt S/S Rote-Louvre Dryer.
1—9'x59' Bannot D. H. Rotary Dryer & Cooler.
3—6'6"x50' D. H. Rot. Dryers.
1—50 gal. Stainless 347, Calandria Still, Agitated, with Condenser.
1—50 gal. Stainless 347, Agitated Tank, Motor Driven.
5—Sperry 18"x18 iron recessed Filter Presses, 18 chambers.
3—450 gal. S.S. Steam Jktd. Kettles.
1—Buflovak 48"x40" Drum Flaker, chrome plated, S/S ends.
1—Oliver Rotary Acid Filter, 6'x9'.
4—Mojonnier, S.S. Vac. Pans, 3', 5', 6'.
3—6'x50' L'ville Rot. Tube Dryers.
1—Day size 30 Imperial Jacketed 75 gal., Sigma Blades.
1—4TH, Mikro Pulverizer, 60 HP., t.e.f.c.
4—Buflovak Atmo. Dbl Drum Dryers 24"x58", 32"x90", 42"x120".
3—Anco 4'x9' Chilling Rolls.
5—Horiz. Ribbon Dry Mixers, 4000 lb., 1500 lb., 500 lb.

Only a Partial Listing

Wanted: Your Idle Machines or Plants
Send List Today

CONSOLIDATED PRODUCTS COMPANY, INC.
Our 38th Year
154 Observer Highway, Hoboken, N. J.
Tel.: HO 3-4425 N. Y. Tel.: BA 7-0600

STORAGE TANKS

—Prompt Shipment—

GLASS LINED TANKS — USED — 3000 gallon capacity. Welded construction — Fully insulated. Equipped with manhead. Suitable for milk, food products, lily white chemicals, solvents and fine lacquers.

VARNISH TANKS — USED 54" diameter x 14'6" high (or long) ¾" Steel — Welded construction — 1700 gallons.

MISCELLANEOUS TANKS—Various sizes and types.

ERMAN-HOWELL DIVISION
LURIA STEEL & TRADING CORP.
332 South Michigan Ave.
Chicago 4, Ill.
Telephone: WEbster 9-0500

NO ifs, ands or buts

BRILL RE-NU-BUILT EQUIPMENT *is the best buy for you*

DRYERS

3—Ruggles Cole 10'x100', 8'8"x70', 8'8"x30'.
1—Vulcan 8'x125' Rotary Kiln.
3—Vulcan 6'x40', 5½'x50', 5½'x40'.
3—Link Belt 3'10"x12", 5'2"x20', 7'5"x 20' S/S.
4—Devine #27 double door Vacuum Shelf 17—59"x78" shelves.
1—Devine Vacuum six 40"x43" shelves.
1—Struthers-Wells 5'x15' nickel Rotary Vacuum.
1—Devine 5'x10' Steel Rotating Vac.
2—Stokes 30"x8', 3'x15' Rotary Vac.
1—Louisville 38x25' Rotary Steam Tube.
4—Buflovak Double Drum 42"x120", 42"x90", 36"x84", 32"x90".
1—Hersey 18"x12' Rotary Hot Air 304 S/S complete with all accessories.
2—Buflovak 6' and 3' dia. Crystallizers.

FILTERS

2—Oliver Rotary, Monel 8'x10', 3'x2'.
1—Feinc 5'x7' S/S Rotary Vac.
1—Feinc 5'x3' Monel. Rotary Vac String.
1—Feinc 3'x1', 316 S/S Rotary Vac String.
1—Swenson Rotary 4'x2' nickel.
1—Oliver 5'x3"x3' rubber lined Rotary Vac Precoat.
2—Sweetland #12, 72 and 36 leaves.
4—Sweetland #3, #5, #7, #10.
2—Sweetland #3, S/S shell and leaves.
1—Niagara 53 sq. ft., 304 S/S.
3—Shriver 36" P&F 42 chambers.
2—Shriver 30" P&F 30 chambers.
6—Sperry 24" P&F 16 chambers.
2—Sperry Aluminum 30"x24".

PULVERIZERS—CRUSHERS

2—Ball & Jewell #1½, #2 Rotary Cutters.
1—Devine 5'x10' steel jacketed Mill.
4—Hardinge Mills 4½'x16", 6'x22", 7'x36".
1—Raymond #40 Imp. Mill, 304 S/S.
4—Patterson 6'x8', 5"x6', 3'x4' brick lined Pebble Mills.
1—NEW Patterson 6'x8' porcelain Pebble Mill 50 HP.
2—National 6"x12" Plastic two-roll Mills.
3—Gayco Air Separators 6', 3', 18" dia.
3—Mikro Pulverizers #4TH, #2.
1—Fitzpatrick Mod D Comminuter S/S.

CENTRIFUGALS

1—AT&M 42" Suspended, 347 S/S.
1—AT&M 40" Suspended, rubber perforated.
1—AT&M 40" Suspended, steel.
1—Bird 40" Suspended, rubber.
3—Tolhurst 40", 32", 26" Suspended, steel.
1—AT&M 36" center slung, rubber.
1—Fletcher 30" center-slung S/S.
1—Fletcher 30" Suspended, steel.
1—Tolhurst 26" Suspended, rubber.
2—Bird 40"x60", 36"x50" Steel, solid bowl Continuous.
2—Bird 18"x28" solid bowl, 310 S/S.
1—Sharples PN-14 Super-D-Canter, S/S.
2—Sharples #C-27, #C-20, S/S Super-D-Hydrators.
2—Sharples #16-P Monel and S/S Super Centrifuges.

FINAL LIQUIDATION

BATON ROUGE, LOUISIANA

1—I.R. Jet Refrigeration Unit complete 136 Tons 50° F to 45° F.
1—Patterson 7'6" Conical Blender rubber lined.
1—Buflovak 6'x5'6" Monel Drum Flaker NEW.
1—Rietz 30' "Thermoscrew" Conveyor Dryer 304 S/S NEW.
1—Pfaudler 250 gal. Hastelloy "C" Reactor.
3—4'x13' closed 316 S/S Reactors, 109—3'6", 316 S/S tubes, 150 psi.
1—2500 gal. 316 S/S jacketed Reactor.
1—Pfaudler 5'x18' Horiz. glass lined 2500 gal.
2—1500 gal. 316 S/S 5'x9' Vert. 200 psi.
1—7500 gal. 316 S/S clad 12'x6'x5'6" cone.
3—Link Belt 316 S/S 18"x12", 18"x10', 18"x7' twin screw Conveyors.

SCREENS

4—Rotex double and single deck 40"x120".
2—Rotex double and single deck 40"x84".
1—Patterson single deck 40"x84", S/S.
3—Robinson single deck 40"x84", S/S.
3—S. W. single deck 40"x84", S/S.

MIXERS

10—Day "Cincinnatus" double arm Sigma Blade, 660, 250, 100 and 50 gals.
2—Baker Perkins 100, 50 gal. Sigma Blades, jacketed.
1—Patterson-Kelly 75 cu. ft. Twin Shell, S/S.
1—Sprout Waldron S/S jacketed Powder, 27 cu. ft.
9—Steel jacketed Powder 50, 225, 265, 350 cu. ft.
1—Struthers-Wells 6'x9' S/S jacketed.
2—Patterson 6' and 5' Steel Conical.
2—Baker Perkins 2 gal. S/S.
1—Robinson 4000# steel Powder.
6—Rodgers 400 to 3000# Powder.
1—Simpson Intensive Mixer #0.
8—NEW Portable Agitators ¼ to 5 HP.
4—Day, Ross 8 and 50 gal., Pony.

TOWERS—REACTORS—CONDENSERS & TANKS

1—7'x30' Propane Tank 1-1/16" shell, 275# W. P.
2—Horizontal Steel Tanks 10'x40', 10'x30', ½" shell.
8—Towers 7'x25'6", 347 S/S, 6'x63', 6'x 34', 5'x96', 30"x70', 24"x42', 12"x30', 8"x20'.
4—Buflovak 4000 gal. steel, jacketed, agitated Reactors 50 psi.
1—10,000 gal. Aluminum Storage Tank 10'x16'x½" shell.
4—Foster Wheeler Karbate Heat Exchangers 188 sq. ft.
3—Heat Exchangers 100, 200 and 300 sq. ft., 304 S/S.
12—Heat Exchangers 50 to 2400 sq. ft. Admiralty and steel.

MISCELLANEOUS

1—Foster Wheeler Dowtherm Unit with super heater, 4½ million BTU.
8—Nash Vacuum Pumps, #H-7, #H-6, #4, #2, #L5, #L3, #MD571.
2—Beach-Russ #50D Vacuum Pumps, 50 cfm.
20—Durimet, Olivite 316 S/S Duriron Centrifugal Pumps 1" to 3".
10—Centrifugal Pumps 60 to 2000 gpm, motor driven.
14—Stokes DDS2, D4, "R", and "T" Tablet Machines.

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Devine #12 & #23 Vac. Shelf Dryers.
1—Stokes 2' x 6' Rotary Vac. Dryer.
2—Albright-Nell 4' x 9' Atmos. Drum Dryers.
1—Buffalo Vac. Drum Dryer 24" x 20".

CENTRIFUGALS & CENTRIFUGES

4—Tolhurst 40" Suspended Type Centrifugals.
6—Centrifugals 12", 30", 40" & 48" Steel, Copper, Stainless & Rubber Lined.
6—Sharples Centrifuges #5A Stainless. Also #6.
3—De Laval Multiple Clarifiers #200, 300 & 301.

FILTERS

#2 Sweetland Filter 12 Stainless Covered leaves.
1—Vallez 41 Stainless Covered Leaf Filter, type 49.
Sperry & Shriver 12" to 36 sq. in. iron & wood.
Gen. Amer. 2' x 1' Rotary Vac. Filter.

KETTLES & TANKS

Pfaudler 500 gal. Glass Lined Jack. Reactor.
Pfaudler 250 gal. Glass Lined Closed Jack. Kettle.
1—Dopp 350 gal. C. I. Jack. Vac. Kettle.
Devine & Stokes Improv. Units 30" & 36" dia.
Devine 1000 gal. closed Jack. Steel Kettle.
1—2800 gal. Vert. agit. Jack. Steel Kettle.
8—Jacketed Kettles 50 to 2300 gals.
1—250 gal. Lead-Lined Kettle.
2—500 gal. vert. Glass Lined Tanks.
50—Stainless Alum., Copper, Glass & Lead Lined Kettles & Tanks. Also new Stainless.

PULVERIZERS & MILLS

3—Mikro Pulverizers #2SI, #2TH.
Pebble Mills 30"x30", 30"x42", 4'x5' & 6'x4'.
Abbe 37" x 30" Chrome Mang. Lined Ball Mill.
#1 Raymond Automatic Pulverizer 20 H.P. motor.
1—Raymond #00 Pulverizer 30 H.P. Complete.
2—#0000 Raymond Mills.
Sturtevant #0.18" Hinged Hammer Mill.
Jeffrey 18½ x 18" Single Roll Crusher.
Day Hercules Spike Crusher 1½ H.P. motor.

Hammer Mills & Pulverizers 3 to 50 H.P.
1—Schutz-O'Neil 20" Pulverizers. Also #1.
Williams #3 & 2xx Hammer Mills.
1—Robinson 18" x 22" Attrition Mill.
1—Lehman 4 Roll W.G. 12 x 36" Steel Mill.
3—Steel 3 Roll Mills 9"x32", 12"x30" & 16"x40".
3—Houchin 18"x36"; 4 Roll Granite Stone Mills.
Ball & Jewell Rotary Cutters Lab. #1 & #2.
2—U. S. & Premier 1½ H.P. Colloid Mills.

MIXERS & SCREENS

Day "Imperial" 75 gal. Jack. Mixer.
Day "Imperial" 150 gal. Jack. Mixer.
Baker Perkins double arm 100, 50 #3 gals.
2—Read 50 & 100 gal. double arm mixers.
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Kux 2½" single punch Preform Machine.
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2—Motor Driven Belt Conveyers.
3—Pony Mixers, 8, 15 and 40 gal.
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8'x125' Rotary Kiln.
10'x200' Rotary Kiln.
5'6"x40' Rotary Dryer.
502-20 L.B. Roto-Louvre Dryer.
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2—Kilby & Sweetland stainless steel filters
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1—Hersey monel 3 x 24' rotary dryer
3—Pfaudler 500 glass lined reactors, jacketed and agitated
6—Patterson 4 x 4' chrome manganese jacketed ball mills
4—Patterson pebble mills, 100—200—250 gallons
1—Colton model AF tube filler, closer and crimper
1—Sharples C-20 stainless steel centrifuge
5—Stokes model E tablet presses
1—Struthers Wells 20 gallon stainless steel jacketed and agitated reactor
6—80 gallon stainless steel agitated autoclaves—500 PSI internal pressure
4—Day pony mixers, 8—15—40 gallons
1—Shriver 36 x 36" cast iron filter press
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• Products listed feature code numbers which show the page on which they appear. L (left), R (right), T (top), B (bottom) indicate ad location; A, B, C, etc. and a, b, c, etc. identify specific product items on an editorial page or in an ad.

• You can get information on any listing by circling it's key number on the Reader Service Postcard (see inside back cover). Replies will come direct from the companies manufacturing the products.

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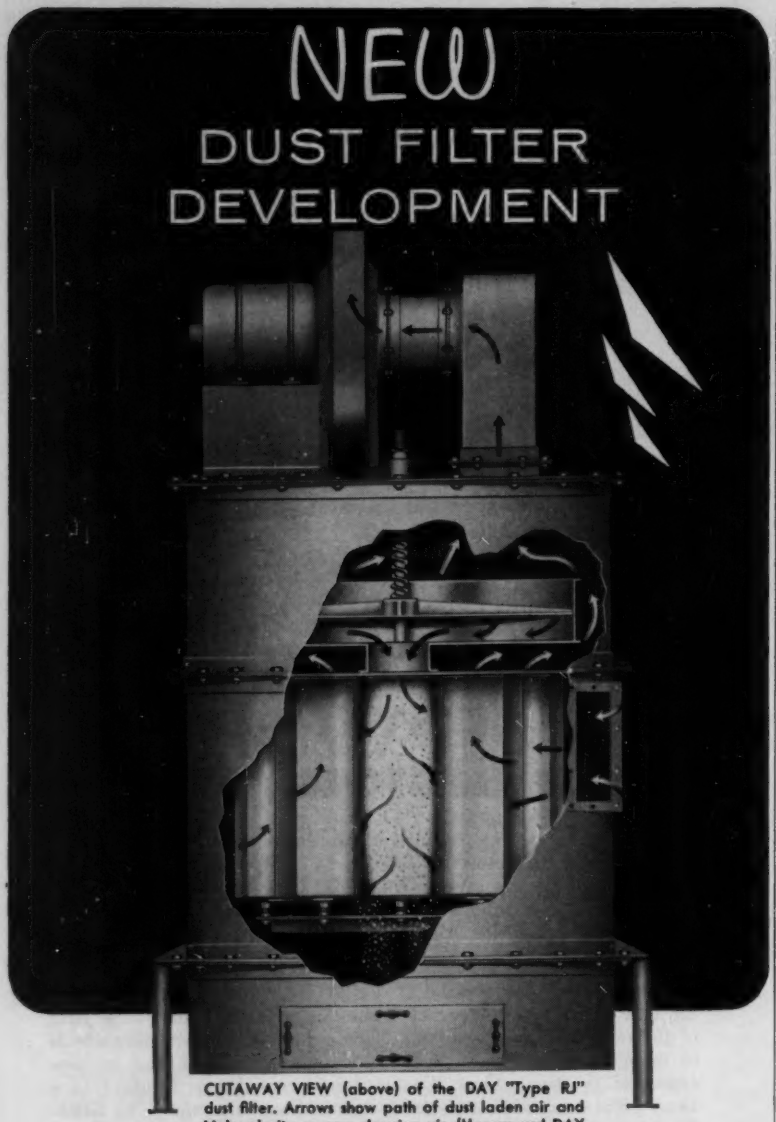
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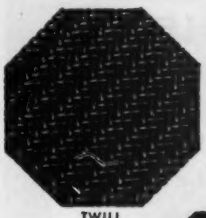
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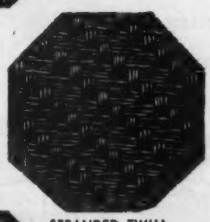
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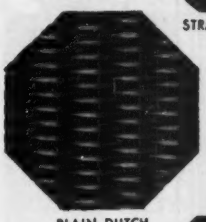
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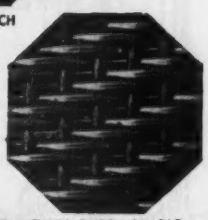


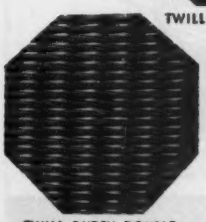

TWILL


STRANDED TWILL


PLAIN DUTCH

Enlarged approximately 3X


TWILL DUTCH SINGLE


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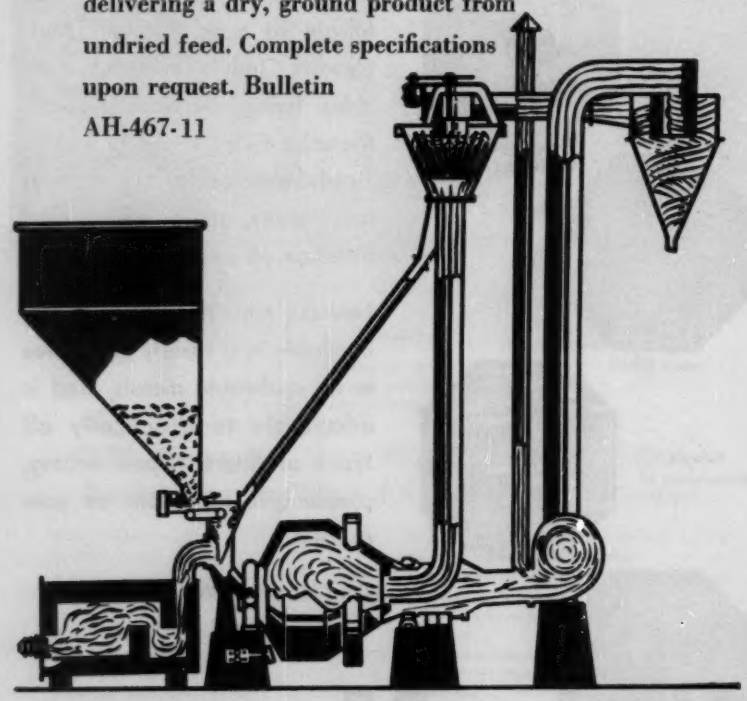
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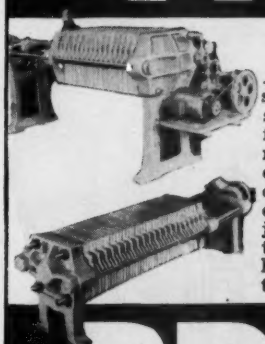
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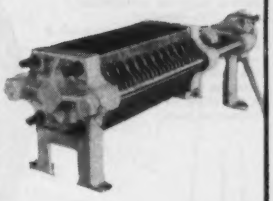
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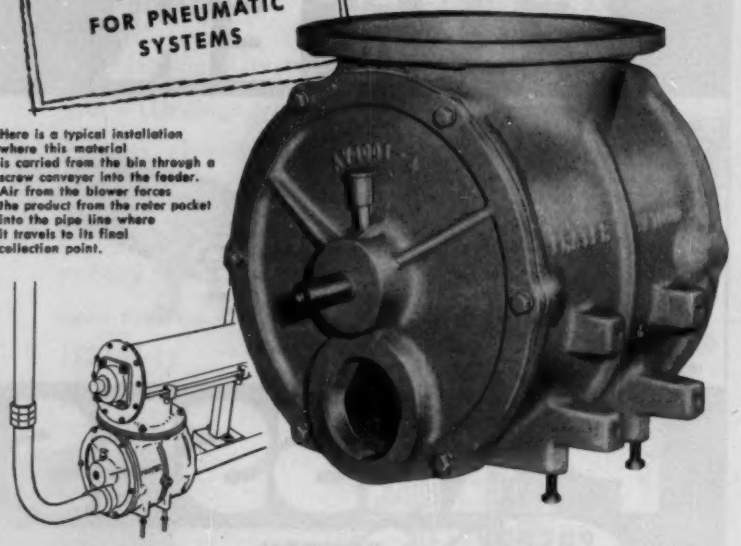
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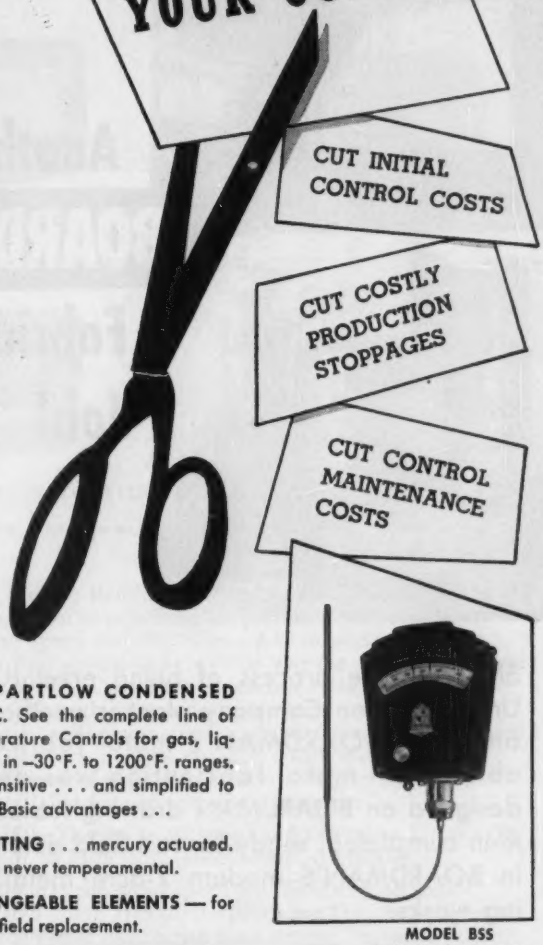
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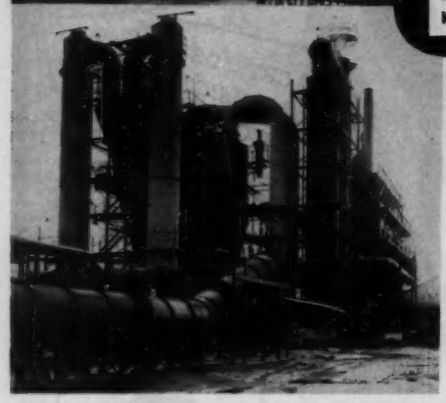
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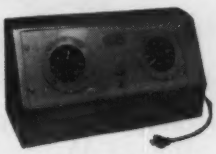
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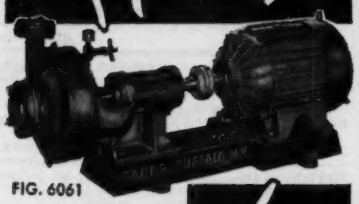


FIG. 6061

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Fig. 19,488

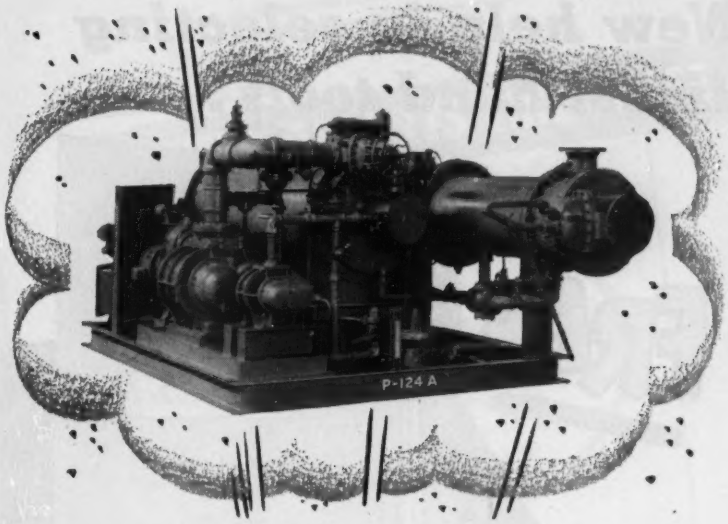
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LITERATURE . . .

Chemicals Petrochemicals.....New processes and controls produce Celanese petro-chemicals to speed up manufacturing cycles, up-grade products, and cut costs. Many profit-making chemicals in new Celanese product index.
418A Celanese Corp. of America.

Cleaners & Polishes.....Company makes available a detailed reference prepared to assist in the power and manual cleaning, polishing and final finishing of various fabricated metals. Request your copy of Bulletin No. 30.
418B Nu Steel Co.

Crotonaldehyde.....Eastman Crotonaldehyde——denaturant . . . chemical intermediate . . . specialty solvent . . . etc. Company announces the availability upon request of descriptive information and product samples.
418C Eastman Chem. Products.

Cyclohexanol.....Cyclohexanol, an intermediate and component of solvent systems in the paint, textile and dry cleaning industries is the subject of a revised Technical Data Sheet. Includes uses and typical reactions.
418D Monsanto Chem. Co.

Depressants.....To cure water problems in oil production, many service companies are now using Atpet 931 . . . an interfacial tension depressant developed by Atlas. Reference contains latest technical information.
418E Atlas Powder Co.

Detergents, Non-Ionic.....Ultra Chemical is in production on Neopone LO . . . a new non-ionic detergent in spray dried bead form. It is new in formula—new in concept. Request product samples and complete data.
418F Ultra Chem. Wks.

Dihydropyran.....Reactivity of the double bond makes possible a wide variety of addition compounds. Hydrogenation yields tetrahydropyran, an excellent solvent & chemical intermediate. Request Bulletin No. 18.
418G E. I. du Pont de Nemours.

1,4-Dichlorobutane.....Low price and availability in tank car quantities should permit commercial development of many syntheses formerly considered too expensive to be practical. For details, see Technical Bulletin.
418H E. I. du Pont de Nemours.

Di-iso Decyl Phthalate.....Recently developed phthalate plasticizer enables you to substantially increase life of your vinyl products—at a volume cost less than that of dioctyl phthalate. Technical literature & samples.
418I Ohio-Apex Div.

Elastomers.....Kel-F Elastomer is a fluorocarbon rubber developed to help solve problems of rubber application under severe operating conditions. For more information, request Booklet, "Kel-F Elastomer."
255 *M. W. Kellogg Co.

Esters, Acrylic.....Contains technical information on line of acrylic esters (ethyl acrylate, n-butyl acrylate, 2-ethylbutyl acrylate, 2-ethylhexyl acrylate)—properties, reactions, containers, etc. Ref. F-7434.
418J Carbide & Carbon Chem.

Ethanolamines . . . . . Company makes available a new, comprehensive book on Ethanolamines—54 p. of information on its uses, physical properties, tables & graphs, & specifications. Request samples.
121 *Nitrogen Div., AC&D.

Ethanolamines.....40 p. Technical Bulletin includes: shipping information; sales specifications; analytical procedure; physical properties; chemical properties; industrial uses; handling & storage; toxicity; etc.
418K Jefferson Chem. Co.

Ethyl Bromide.....When combined with another intermediate, ethyl bromide can result in a higher yield of finished product with overall lower costs and higher production. Catalog describes full line of pure Bromides.
418L Michigan Chem. Corp.

* From advertisement, this issue.

Ethylene Oxide.....Prepare non-ionic detergents by using high purity Nitrogen Div. ethylene oxide. For data and a bibliography of literature, request "The Manufacture of Non-Ionic Detergents from Ethylene Oxide."
419A Nitrogen Div., AC&D.

Finishes, Paint.....The versatility and wide application of Nubelite, a custom-formulated industrial paint finish for use on any metal product, is highlighted in a new comprehensive, fully illustrated 20 p. Brochure.
419B Glidden Co.

Flatting Agents.....Announces the availability of a Technical Bulletin on the use of company's Syloid 244 product for flatting vinyl lacquers, to give a low-gloss effect. Extensive tests are reported in detail.
419C Davison Chem. Co.

Fluids & Lubricants, Synthetic.....52 p. booklet describes Ucon synthetic fluids and lubricants. Covers properties, applications and characteristics of these polyalkylene-glycol derivatives. Request Form No. 6500D.
419D Carbide & Carbon Chem.

Furan.....The chief interest in furan has centered on its use as an intermediate in the production of pharmaceuticals and plant growth regulants, Technical Bulletins on properties and applications available.
419E E. I. du Pont de Nemours.

Glycols.....Illustrated 62 p. describes uses & suggested applications for glycols. Tabular data includes properties, shipping information, specifications, test methods & constant-boiling mixtures. Ref. No. F-4763C.
419F Carbide & Carbon Chem.

Gums, Water-Soluble.....The fascinating story of the history, characteristics, and uses of famous gums—arabic, tragacanth, karaya, irish moss, locust bean—is presented in "The Story of Water Soluble Gums."
419G Jacques Wolf & Co.

Hydrogen Peroxide....."Method of Measuring H_2O_2 Concentration in More Concentrated Solutions" gives directions for permanganate titration in analyzing H_2O_2 solutions. Request Bulletin No. 23.
419H Buffalo Electro-Chem. Co.

Hydrogen Peroxide....."Albone", an aqueous hydrogen peroxide solution, is available in grades containing 35% and 50% by weight H_2O_2. Descriptive literature contains information on properties and applications.
419I E. I. du Pont de Nemours.

Hydrogen Peroxide.....Product literature describes Becco hydrogen peroxide 35% Formula F—a grade of hydrogen peroxide designed for use in food processing. Covers properties & specifications. Bulletin No. 41.
419J Buffalo Electro-Chem. Co.

N-(2-Hydroxypropyl) Ethylenediamine.... Monolene, new "water white" liquid of interest to those concerned with reactions involving primary & secondary amine groups, as well as secondary hydroxyl groups. Data & sample.
419K Wyandotte Chem. Corp.

12-Hydroxystearin.....Describes Castorwax 12-Hydroxystearin...the low cost synthetic wax with valuable plus-features. Includes details of the many uses of Castorwax and formulation information. Technical Bulletin 7.
419L Baker Caster Oil Co.

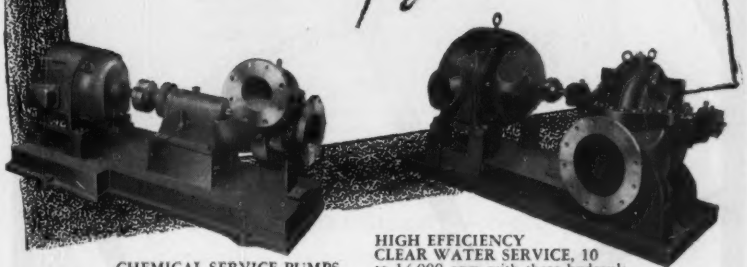
Isopropyl Ether.....New reference discusses uses for isopropyl ether and contains up-to-date information on physical and physiological properties, specifications, solubility and shipping. Technical Bulletin No. F-40003.
419M Carbide & Carbon Chem.

Latex.....New 16 p. Service Bulletin on use of Hycar latices in textiles now available. Bulletin features a chart which shows physical properties of Hycar latices and typical fields of application for each.
419N B. F. Goodrich Chem. Co.

* From advertisement, this issue.

FIELD REPORTS LIKE THESE

"Incidentally, the Engineer says that this "Buffalo" pump has been running 24 hours a day on alternate weeks since 1936 when they made their last repairs on it, and all he has done is spend about 10¢ for packing."

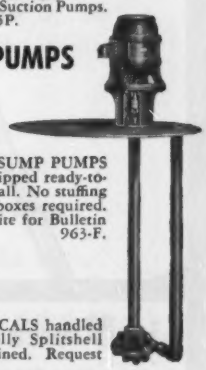


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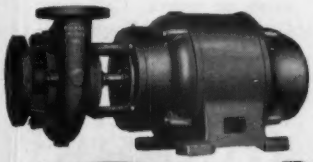
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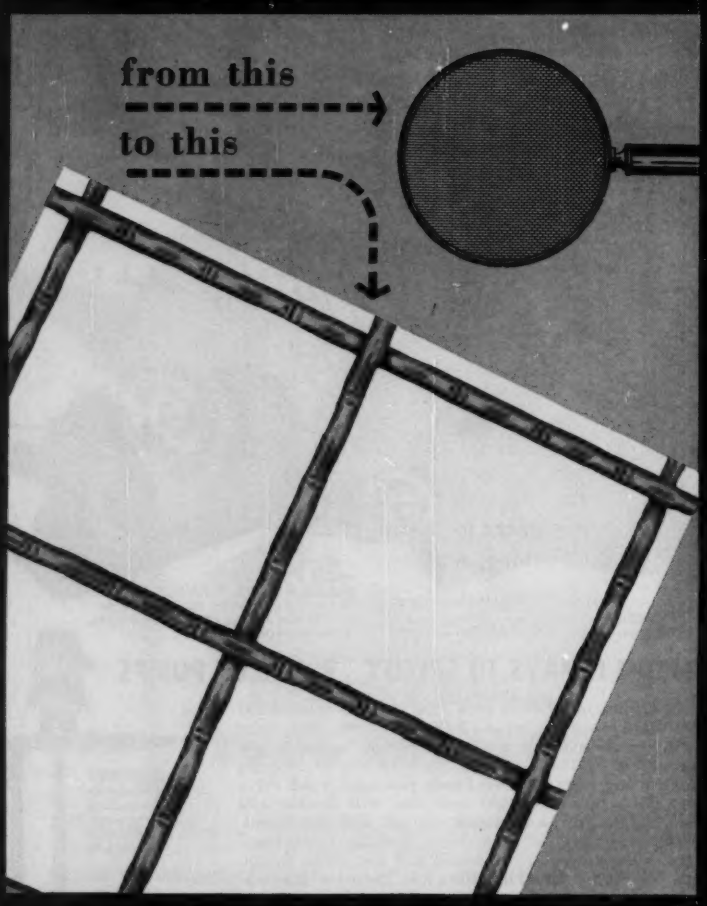
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LITERATURE . . .

Lithium.....Lithium in nuclear energy has been the subject of technical study by the staff of the Lithium Corp. Lithium metal, 2 metal derivatives, & 15 salts are available for study. Data sheets.
7B *Lithium Corp. of America.

Lithium Aluminum Hydride.....A specific agent for numerous organic reductions. Reference gives composition, properties, solubility, applications, typical reductions, handling, safety & storage data. Bul. 401-D.
420A Metal Hydrides.

Lithium Carbonate.....Issues a Technical Bulletin on lithium carbonate. In reference is detailed information on chemical analysis, solubility in water at various temperatures, suggested uses & other material.
420B American Potash & Chem.

Lubricants.....Fluorolubes, polymers of trifluorovinyl chloride, won't break down in the presence of oxygen, hydrogen peroxide or other reactive chemicals. Won't be injured by heat. Request complete data.
158d *Hooker Electrochem. Co.

Lubricants, Silicone.....Cut your valve maintenance with Dow Corning valve seal, the non-melting, chemical-resistant silicone lubricant. Effective at temperatures from —40 to 500 F. Request sample.
R445 *Dow Corning Corp.

2-Methyl-5-Ethyl Pyridine.....Used as a solvent and acid acceptor for manufacture of vat dyestuffs, and for preparation of vitamins, pharmaceuticals and pyridine-type monomers. For details, request Form F-7621B.
420C Carbide & Carbon Chem.

Monomers.....Describes MG-1...a high-boiling, low-viscosity monomer which is an excellent dispersant for plastisol-grade vinly chlorjde resins. Covers characteristics, applications, properties, etc. Ref. F-8794.
420D Carbide & Carbon Chem.

Monopentaerythritol.....Issues upon request a new Technical Bulletin on "Monopentek," Heyden's monopentaerythritol. Includes data on specification, properties, solubility, reactions, uses, etc. Bulletin PE 11-55.
420E Heyden Chem. Corp.

Oils, Perfume....."Rhodia Perfume Oils for Cream Shampoos" describes a series of new perfumes created especially for cream shampoos prepared from the newest aliphatic alcohol sulfates and like products.
420F Rhodia, Inc.

Pentaerythritol.....Reduce purchase & inventory problems with Double Duty P. E. Costs no more than "technical" grade, yet it qualifies for both premium & low-cost alkyd resin applications. See Celanese P. E. Bulletin.
420G Celanese Corp. of America.

Phosphates.....You can buy mixed carloads of phosphates from Maas...the largest producer with the most complete line of phosphates and photo chemicals in the West. For details, request descriptive Folder.
420H A. R. Maas Chem. Co.

Polyvinyl Acetate Beads.....For beads that are free-flowing in all viscosities ...specify Vinac Polyvinyl Acetate Beads. Makes available upon request Data Sheets, suggested formulations, free product samples, etc.
420I Colton Chem. Co.

Polyvinyl Acetate Emulsions.....Valuable reference made available to help you determine the Darex PVAc best suited to your needs. Includes description of features, specifications, typical end uses. Brochure No. E-12.
420J Dewey & Almy Chem. Co.

Potassium Borohydride.....Detailed reference gives composition, properties, solubility, applications, typical reductions, handling, safety and storage information. Request copy of Technical Bulletin No. 301-B.
318a *Metal Hydrides.

* From advertisement, this issue.

Pyrrolidine.....This cyclic secondary amine functions as both a catalyst & reaction intermediate. Unusual compounds can be made by reactions involving addition, condensation, acylation, etc. See Bulletin No. 28.
421A E. I. du Pont de Nemours.

Resin Curing Agents, Epoxy.....Carbides's wide selection of amine curing agents enables you to select the preferred "pot life" for your epoxy resin application...from a few minutes to several hours. Report F-8665.
421B Carbide & Carbon Chem.

Resins, Ion Exchange.....New Nalco bulletin gives technical data on Nalcite SAR & SBR anion exchangers ... including complete up-to-the-minute information on silica removal. Request your copy. Bulletin No. 57.
301 *National Aluminate Corp.

Resins, Polyamide.....“Versamids — A Demonstration in Resin Versatility” contains data about Versamids plus information on each of the eight types currently marketed by General Mills. Request Bulletin No. 11-E.
236-7 *General Mills.

Resins, Polyethylene.....Tough, flexible Alathon polyethylene resin stands up well against abrasive slurries. Widely used in industrial pipe applications. Offers complete information on the properties and applications.
243a *E. I. du Pont de Nemours.

Resins, Polyvinyl Chloride.....Reference describes Pliovic EDB90V and Pliociv EG90V . . . electrical grade—Underwriters' approved—vinyl resins. Includes data on types and typical properties. Ref. No. 55-179.
421C Goodyear Tire & Rubber Co.

Resins, Styrene-Butadiene.....Maintaining color uniformity is no longer a problem with masonry paints based on Pliolite S-5, Styrene-Butadiene resin. See “Color Uniformity of Pliolite S-5 Finishes,” Ref. No. 55-274.
421D Goodyear Tire & Rubber Co.

Resins, Synthetic.....8 p. reference describes the Alpex line of synthetic resins. Included are sections on: general properties; physical properties; compatibility of Alpex with various materials; etc.
421E Alkydol Labs.

Resins, Synthetic.....Bulletin describes the Piccolyte line—the low-cost resin with 7 outstanding advantages: pale color; economical; permanent; waterproof; many grades; neutral; low-cost. Request your copy.
421F Pennsylvania Indus. Chem.

Resins, Tetrafluoroethylene..... Teflon tetrafluoroethylene resins used extensively in process industries. Offer chemical inertness, high heat resistance, low-temperature toughness, etc. Properties & applications.
243b *E. I. du Pont de Nemours.

Silicone Products.....Announces release of “1956 Reference Guide to Dow Corning Silicone Products.” Products grouped by physical form & cross-indexed by usage. Thoroughly illustrated with charts, tables, graphs, etc.
421G Dow Corning Corp.

Soda, Caustic.....Wall chart (17" x 23") gives 37 specific, successful suggestions for safely handling solid, liquid & flake caustic soda. Safety recommendations cover first aid measures, protective practices, etc.
421H Diamond Alkali Co.

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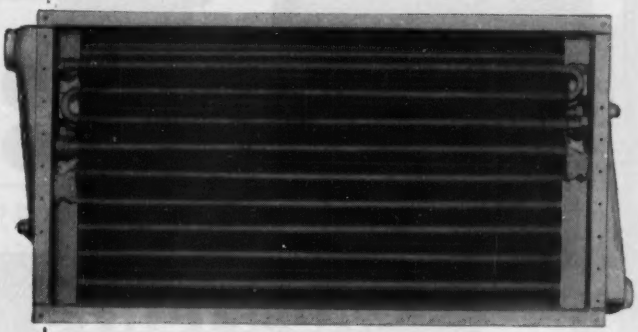
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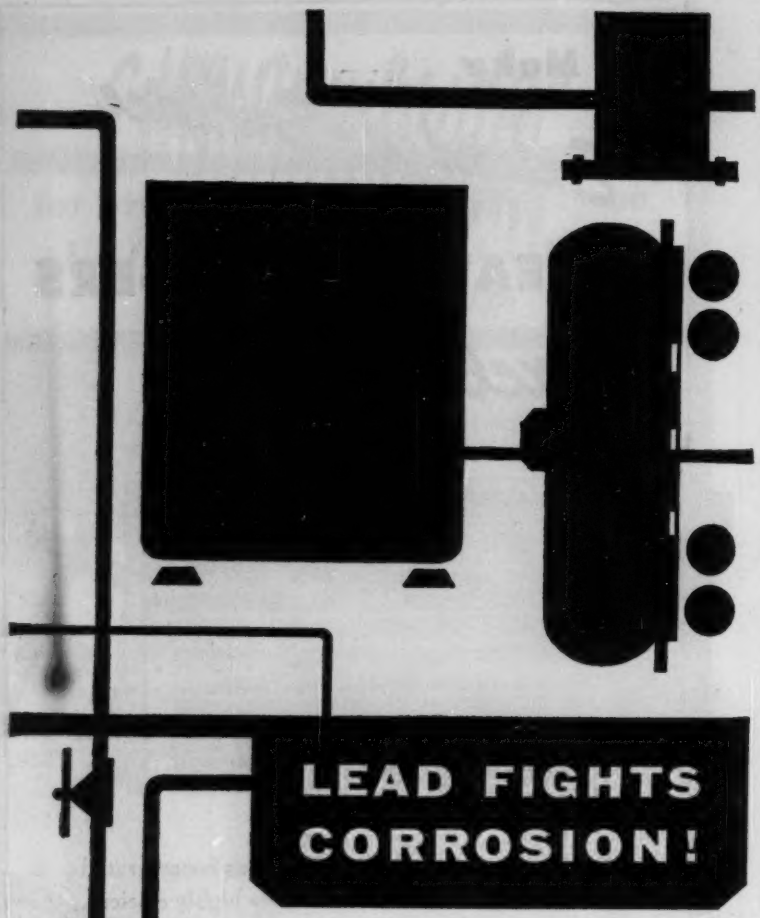
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LITERATURE . . .

Sodium Benzoate.....Company makes available technical data on its line of sodium benzoate—flake or powdered. Both are dust-free to prevent sneezing. For more complete information, request literature.
158b *Hooker Electrochem. Co.

Sodium Borohydride.....MH sodium borohydride, $MaBH_4$, will reduce esters, acids, acid anhydrides, and acid halides. Announces the availability of detailed Bulletin 502-F and typical reduction procedure.
313b *Metal Hydrides.

Sodium Hydride.....Makes available a detailed technical reference containing information on: composition; properties; solubility; applications; typical reductions; handling; safety; storage. Tech. Bul. 507-C.
422A Metal Hydrides.

Sodium Nitrite.....Sodium Nitrite is being used, alone & in combination with other materials, for the cleaning, neutralizing & protection of metals in diverse applications. Request new Book & sample.
147 *Solvay Process Div.

Sodium Phosphates.....Announces availability of a valuable reference, "Sodium Phosphates"—an easy-reading booklet giving a brief yet complete review of technical and commercial aspects of sodium phosphates.
422B Monsanto Chem. Co.

Sodium m-Silicate.....Valuable data on Drymet anhydrous—the most highly concentrated form of sodium m-Silicate. Drymet File Folder contains complete technical information and suggested formulations.
BB323 *Cowles Chem. Co.

Solvents.....A remarkably versatile series of solvents, Poly-Solvs are now available in commercial quantities—drums, tank cars, compartmented tank cars—from Doe Run plant at Brandenburg, Ky. Data Sheets and samples.
422C Olin Mathieson Chem. Corp.

Solvents & Solvent Oils.....New Bulletin furnishes technical information on Picco Solvents and Solvent Oils. Charts showing typical analysis and distillation range for various grades are included in reference.
422D Pennsylvania Indus. Chem.

Stearates, Metallic....."Stearates, Their Properties & Uses" lists composition of 46 metallic stearates, shows industries in which they are used & presents analysis of recommended applications. 36 p. Bulletin 55-2.
422E Witco Chem. Co.

Surface Active Agents.....Aerosol surface active agents feature great versatility: crystal growth control; leak testing; emulsion polymerization; dry cleaning. Booklet discusses various grades and profitable uses.
422F American Cyanamid Co.

Surfactants.....Igepons are important in many industries, including cosmetics, textiles, detergents, paper, leather, agricultural and industrial chemicals, to improve a product or process. Request information and samples.
422G Antara Chem.

Surfactants, Non-Ionic.....Numerous uses: insecticide concentrates; plastisol and organisol stabilizers; pharmaceutical and cosmetic emulsifiers; latex paint leveling and defoaming agents; etc. Details in Glyco Catalog.
422H Glyco Products Co.

Tetrahydrofuran.....Finds increasing use in applying top coats of high molecular weight polyvinyl chlorides to polyvinyl chloride sheeting and supported fabric. For complete information, request Technial Bulletin.
422I E. I. du Pont de Nemours.

Thickeners, Synthetic.....Synthetic thickening agents, which are suggested as replacements for natural thickners in a broad range of industrial applications, are the subject of a 28 p. booklet available upon request.
422J Monsanto Chem. Co.

* From advertisement, this issue.

Thixcin.....A fine white powder that swells in aliphatic solvents & most oil-based compositions to form a loosely knit lattice structure of tremendous supporting power. Request technical data and product sample.
423A Baker Castor Oil Co.

Tripentaerythritol, Technical.....Offers a Technical Bulletin on "Tripentek," Heyden's tripentaerythritol technical. Includes data on properties, solubility, uses, containers, handling, etc. Request Bulletin PE 3-55.
423B Heyden Chem. Corp.

Construction Materials

Adhesives.....Data Charts list form, percentage solids, average viscosity, fastest optimum curing time, lowest optimum curing temperature and application suggestions covering thirty adhesive formulations.
423C Rubber & Asbestos Corp.

Adhesives.....Describes Polyoses—a new group of synthetic water-soluble adhesives for use in: prepared pastes; remoistening gums; paper laminants; mucilage formulations. Request copy of Polyose Technical Bulletin.
423D Corn Products Refining Co.

Alloys.....Hastelloy alloys last for years under severe corrosive conditions. Company makes available a booklet describing these alloys and samples for testing alloys under actual operating conditions.
229 *Haynes Stellite Co.

Aluminum Products.....Brochure describes complete range of Harvey Aluminum's wrought aluminum mill products. Illustrations & text cover extruded shapes, structurals, machining stock, etc. "Aluminum Products."
423E Harvey Aluminum.

Coatings, Protective.....Describes Amercoat No. 87—a heavy bodied, high solids vinyl resin coating which can be applied at thicknesses up to 10 mils in one coat. General, physical & chemical properties detailed.
233 Amercoat Corp.

Coatings, Protective.....A new 12" by 18" comparative guide form blank available for your use in comparing coating systems. Shows method to arrive at cost per sq. ft. per year of service for each system considered.
296 *Carboline Co.

Coatings, Spray.....Rokide spray coatings are applied in a molten state by means of a metalizing type spray gun. These hard, adherent crystalline refractory oxides offer many advantages. Request detailed information.
49 *Norton Co.

Electroplating Charts.....Designed to be invaluable in costing & every other operation connected with precious metal electroplating. Provides all related & comparative data on gold, rhodium, palladium, platinum, silver.
423F Technic, Inc.

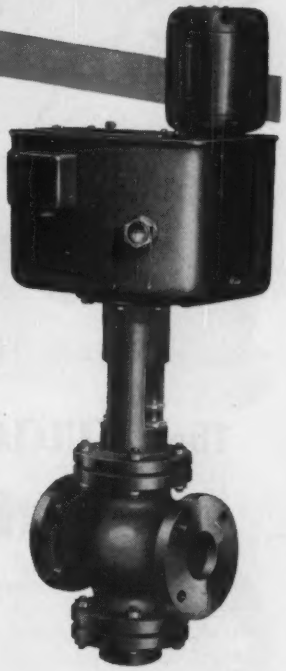
Fabrication, Plate.....Illustrated, 12 p. covers dozens of typical examples of plate fabrication work done by the company for chemical, refining, petrochemical, food and other process industries. Request Bulletin PF.
14 *Downingtown Iron Wks.

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FEATURES:
Valve Stem Speed...0.5 in/sec Valve Stem Thrust...600 lbs.
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Input Coil Resistance.....3,000-18,000 ohms
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Write **for Bulletin No. 200 for complete information on how "EHVA" control might be adapted to your control system.**

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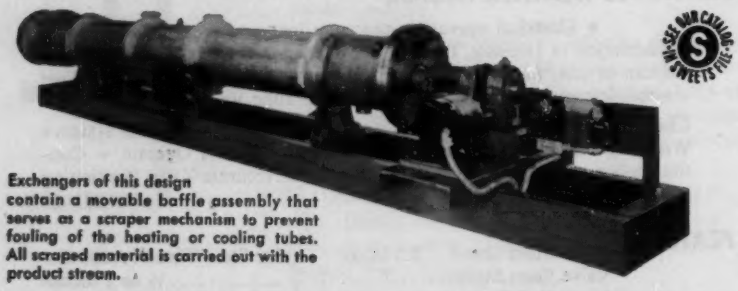
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LITERATURE . . .

Fabrication, Polyester Bonded Fiber Glass Products.....Homogenous for longer service & greater strength—precision fabricated for low cost installation—smooth, friction reducing surfaces. Properties & applications. 8 p.
424A Du Verre.

Fabrication, Stainless Steel.....Feature the techniques of fabricating equipment with round corners for efficient service—round corners are stronger . . . easier to clean. Guide provides complete information.
298 *S. Blickman, Inc.

Linings, Tank.....Company offers a new 12 p. booklet on its Tygon linings. Tygon's resistance to acids & alkalies permits its use in all the usual lining & covering jobs. Request Bulletin No. TL-526.
102 *U. S. Stoneware Co.

Linings & Tile Tanks.....Designed & installed to meet the exact chemical & physical requirements of each installation, Stebbins linings & tile tanks are famous for their efficiency & economy. Request Bulletin A-153.
435 *Stebbins Engrg. & Mfg. Co.

'aints, Protective.....New catalog reference describes "Seal-Kote" vinyl plastic all-purpose paint. Profusely illustrated, it recommends "Seal-Kote" for a wide range of applications around homes, farms and industry.
424B Wooster Sealkote Co.

Steels.....16 p. booklet, "Special Steels for Industry," gives details as to stainless steels, electrical materials, Carmet carbide materials, and tool steels manufactured by the organization. Contains numerous charts.
424C Allegheny Ludlum Steel Corp.

Titanium Sponge.....Resists chlorides & other corrosive chemicals as no other structural metal can. Offers general booklet on titanium plus new technical bulletin with data on corrosion-resistant properties.
73 *E. I. du Pont de Nemours.

Electrical & Mechanical

Casters & Wheels.....Featuring Darnelloprene treads (a soft resilient Neoprene rubber compound) . . . casters offer ease of movement, quietness, and protection for floors. Manual contains complete information.
L415 *Darnell Corp.

Drives.....Illustrated booklet, "How to Care for Jr.," just published, describes the simple, but comprehensive program available to keep Reliance V*S Jr. Drives in operation at peak efficiency. Bulletin H-2104.
424D Reliance Elec. & Engrg. Co.

Drives, Dry Fluid.....Flexidyne easily handles difficult starting problems, and gives a new kind of protection against shock and overloads. For complete product information, request company's Bulletin No. A-640.
60-1 *Dodge Mfg. Corp.

Drives, Gear.....Describes the U. S. Holloshaft right angle gear drive... for non-electrical locations. Ruggedly designed for continuous duty. Profusely illustrated reference covers all outstanding features. Form F-1775.
424E U. S. Elec. Motors.

Drives, Silent Chain.....88 p. brochure offers detailed engineering data. Covers design and application information, drive components and accessories, operational and technical data, etc. Request Book No. 2425.
87 *Link-Belt Co.

Expanders, Tube.....No. 255 for average sheets and No. 270 for thick or multiple sheets. Tube expanders are recommended for use with any controlled rolling motor for uniform expansion of tubes. See Bulletin.
BL325 *Gustav Wiedeke Co.

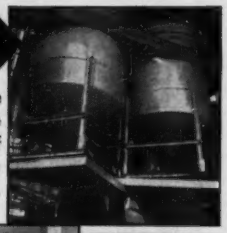
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Inside—Outside Topside!

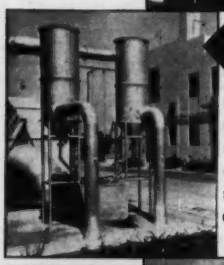
MULTI-WASH

DUST COLLECTORS need no productive floor space

Inside



How Multi-Wash collectors can be installed, up off the floor, inside the building.



Outside

Installation of collectors outside the plant, conserving floor space for productive work.

Topside



Battery of Multi-Wash units installed on the roof of a large production factory.

Schneible Multi-Wash Collectors were designed to save money in many ways. Not the least, is the variety of methods of installation. In a majority of instances Schneible installations are operating without taking away any valuable production space.

This means profit from every foot of floor space, plus cleaner, more healthful working conditions that increase productive effort.

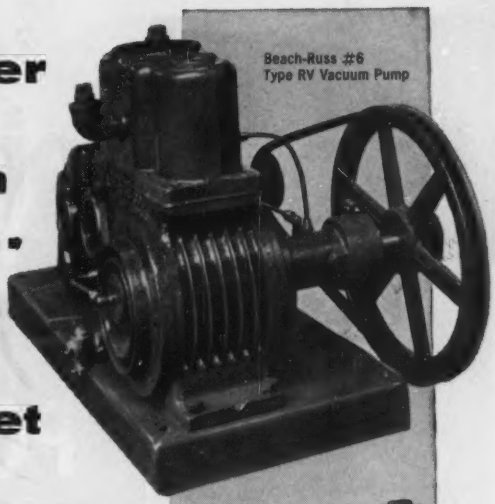
Specify Schneible Dust Control for simplicity and efficiency.

CLAUDE B. SCHNEIBLE CO.
P.O. Box 81, North End Station
Detroit 2, Michigan

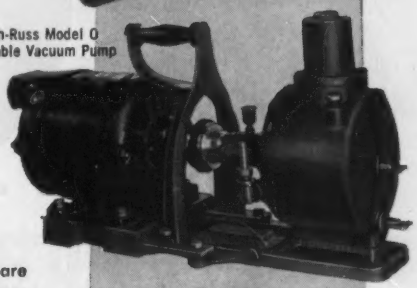
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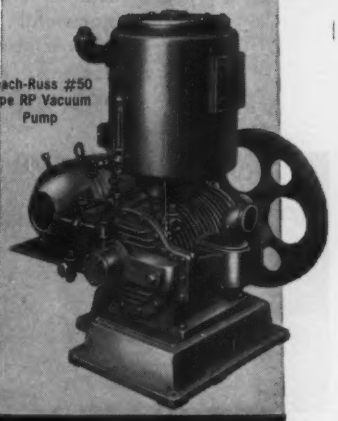
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Beach-Russ #6 Type RV Vacuum Pump



Beach-Russ Model O Portable Vacuum Pump



Beach-Russ #50 Type RP Vacuum Pump

Beach-Russ High Vacuum Pumps are available in a complete range of types and sizes to meet any vacuum need. From the smallest 1 c.f.m. portable unit for testing and dehydrating work, to the large 1800 c.f.m. units for process operations, these precision-built

BEACH-RUSS Vacuum Pumps give

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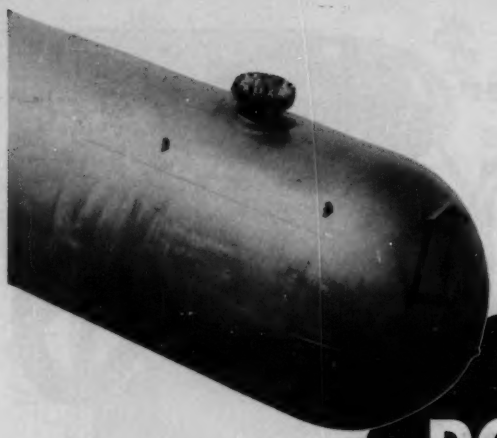
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Length - 64'
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Capacity - 30,000 gallons liquid

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NEW YORK OFFICE: GRAYBAR BUILDING

LITERATURE . . .

Electrification, Crane.....Gives drawings & data for ordering aluminum Inverted-Y Conductors, supports & collectors for any normal application requiring currents in amounts of 300-1000 amperes. Catalog 2021-A.
426A Cleveland Crane & Engrg. Co.

Gaskets, Teflon-Jacketed.....Fully illustrated reference covers Chempro's lines of teflon jacketed gaskets, solid ring gaskets, teflon expansion joints and special teflon, gaskets. Request Bulletin No. CP553.
B325b *Chemical & Power Products.

Illuminators, Gage.....Gage illuminators provide even, no glare, low cost lighting for gages, rotameters, etc. Illuminators use the principle of solid wedge lighting to give you clear, even light. Data Unit.
L445 *Jerguson Gage & Valve Co.

Motors.....Announces new line of general-purpose ball bearings polyphase motors in rerated NEMA frame sizes 182 thru 326. Suitable for indoor or outdoor use. Describes construction features in Bulletin No. MU-202.
18 *Wagner Elec. Corp.

Motors.....Describes U. S. Motors—a brief presentation of the complete line. Includes data on: U. S. Uniclosed motors; U. S. Varidrive motors; U. S. Syncrogear motors; U. S. Verticlosed motors; etc. Form F-1878.
426B U. S. Elecl. Motors.

Motors, Aircraft.....Fully illustrated, 8 p. describes U. S. Aircraft Motors . . . high frequency induction type. Features: alternating current; 3-phase, high frequency; 400 cycles; ¼ hp to 16 hp; etc. Form F-1535.
426C U. S. Elecl. Motors.

Motors, D-C.....Issues new 12 p. publication on fractional hp direct-current motors & equipment. Covers full line for direct application & built-in use. Includes features, ratings, specifications, etc. Ref. No. GEA-6068.
426D General Elec. Co.

Motors, Gear.....Describes completely new line of Gearmotors & Motogears. Includes selection data together with features of construction, load classifications, dimension tables, etc. Illustrated, 28 p. Book 2447.
426E Link-Belt Co.

Packings, Ring.....Furnishes complete descriptions of the Chempro lines of teflon ring packings, teflon impregnated asbestos packings, V-type packings and the patented teflon seal cage. Bulletin No. CP552.
B325a *Chemical & Power Products.

Reducers, Motor.....Motors can be interchanged or replaced in minutes with the all-steel Falk motoreducer. Replacement is not limited to original make of motor. For more information, request Bulletin No. 3100.
100 Falk Corp.

Relays, Electrical.....Describes the Loadtrol . . . an inexpensive electrical relay. Includes data on: construction; dimensions; capacity; regulation; applications; typical installations; etc. Bulletin No. 340.
426F Technalectric Co.

Seals, Mechanical.....The type 9 seal solves innumerable problems where difficult-to-handle liquids & gases are involved . . . at pressures up to 750 psi. For more complete information, request literature.
297 *Crane Packing Co.

Seals, Mechanical, Rotary.....Company announces the availability of a new 8 p. reference which shows how you get maintenance-free sealing that slashes fluid mixing cost to a new low. Illustrated Bulletin B-111.
123h *Mixing Equipment Co.

Teflon Products.....Illustrates various of the many special molded & machined parts firm has fabricated from pure teflon, glass-filled teflon, glass- & carbon-filled teflon & zircon-filled teflon. Bulletin No. CP554.
B325c *Chemical & Power Products.

* From advertisement, this issue.

MASS-TRANSFER OPERATIONS

JUST OUT! An introduction to diffusion and the techniques used in industrial applications of mass-transfer operations. Covers equipment design and operation, humidification and dehumidification, gas absorption, liquid extraction, ion exchange, drying, leaching, and other unit operations. Presents an integrated treatment by discussing both stagewise and continuous-contact equipment and methods for each operation. **By Robert E. Treybal, Prof. of Chem. Engrg., New York Univ. 666 pp., 348 illus., $9.50**



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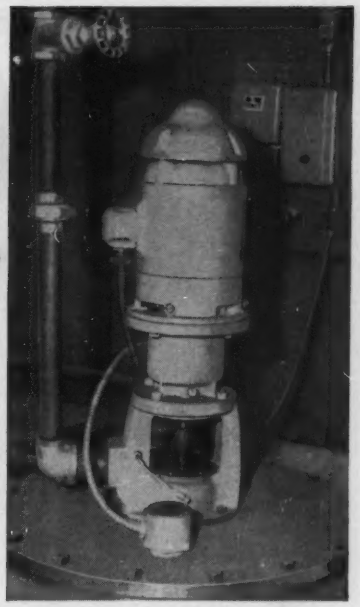
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Solution

for a "PACKAGE" of Pump Problems



One of six Deming Turbine Pumps in condensate return service at The Morgan Engineering Company, Alliance, Ohio.

Deming Turbine Pumps

Plant engineers at The Morgan Engineering Company, Alliance, Ohio, leading manufacturer of cranes, presses and steel mill equipment, had a "package" of pump problems.

The Job was pumping hot condensate from steel sumps for return to steam boilers.

The Equipment included four obsolete condensate pumps with 3 HP electric motors and float controls.

The Problem was the failure of the original equipment to meet the job requirements efficiently and economically. Proper lubrication of the pump bearings was found impossible to provide. Frequent replacements of bearings and impellers was necessary. Float equipment gave almost constant trouble due to surges of steam. Here was a "package" of problems.

The Solution started by calling in the local Deming Distributor. Working "elbow to elbow" with the plant engineers, it was decided that Deming Vertical Turbine Pumps offered definite advantages.

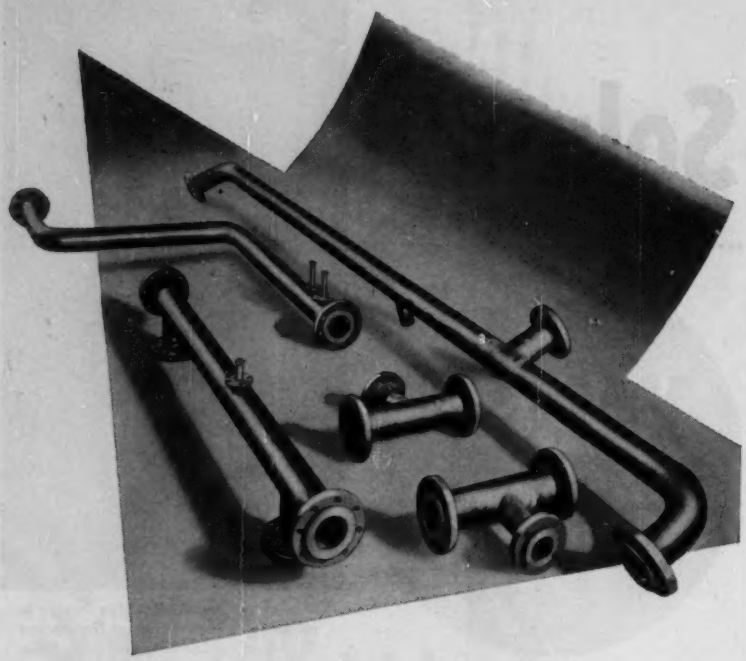
1. The Deming Vertical Submerged Pumps with floatless controls eliminated the former float control troubles.
2. Only 2 HP electric motors were required by the Deming Turbine Pumps. The former condensate units required 3 HP motors.
3. Trouble in lubricating the bronze bearings of the condensate units was eliminated. Deming Turbine Pumps are self-lubricating (with the water flowing constantly through the pump when operating).
4. Using 1/3 less horsepower, the Deming Turbine Pumps did more work with a minimum of maintenance and at considerably less overall cost of operation.

Ask your nearest Deming Distributor or write us for a free copy of illustrated BULLETIN 4700 on Deming Vertical Turbine Pumps.

THE DEMING CO. • 521 BROADWAY • SALEM, OHIO

CALL YOUR **DEMING DISTRIBUTOR** *for help on pumps!*





Tough piping problems made easier with AMPCO* PIPE

. . . the pipe that resists corrosion and velocity damage, withstands mechanical abuse

Put Ampco Pipe on your tough, liquid-handling jobs, and, mister, you've got something. First of all you've got pipe that's easier and less costly to install. It stands up under wrenches and hammers without thread distortion and subsequent leakage. It is readily welded with shielded arc procedures. "On-the-job" changes and maintenance may be done by the average weldor.

Pipe made from this unique aluminum-bronze alloy is hard, yet it's unusually tough — gives you Brinell hardnesses of 150 and tensiles up to 70,000 psi. It has high strength-to-weight ratios.

But here's the best part of the story. It is highly resistant to many acids and caustics. It has high velocity tolerance—permits flow rates up to 18-20 fps. It withstands the action of abrasive solids in suspension and resists cavitation-pitting. It combines the advantages of many different pipe materials without their drawbacks.

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Burbank, California

PM-19

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LITERATURE . . .

Tools & Wrenches.....Contribute greater efficiency to assembly and maintenance operations by using Snap-On tools. For complete data request free catalog of industrial wrenches and hand tools. Yours for the asking.
418 *Snap-On Tools Corp.

Transmission Equipment, Power.....Illustrated, 24 p. describes line of power transmission equipment. Includes: variable speed pulleys; wide v-belts; sheaves; motor bases; countershafts; Select-O-Speed Transmission.
428A Lovejoy Flexible Coupling Co.

Transmitters, Power.....Unequalled for repeated start-stop machine operation. Use of transmitters makes it possible to simplify machines, reduce costs, improve operation, etc. Details in Bulletin CE-3303.
269a *Diehl Mfg. Co.

Turbines, Solid-Wheel.....Feature reliable, trouble-free operation. Rugged construction and superior design result in savings by keeping maintenance costs down to a minimum. Full details in Bulletin No. S-116.
68 *Terry Steam Turbine Co.

Handling & Packaging

Belting, Conveyor.....Release a wall chart on the proper selection & maintenance of conveyor belting. The chart (23 in. x 33 in.) contains 12 practical maintenance tips for getting more life out of belts.
272-3 Hewitt-Robins.

Conveyor Systems.....Brochure describes Rapistan Controlled Flow conveyor systems. Systems prevent usual flow-stoppage causes that reduce effectiveness of an ordinary gravity and power conveyor system. Illustrated.
428B Rapids-Standard Co.

Conveyors.....Handle packages, parts, units—faster—at reduced cost with gravity or power roller, belt, slat, chain, wheel or push-bar conveyors. Specifications, drawing & application data in Bulletin No. 309.
432 *Standard Conveyor Co.

Latex Handling, Synthetic.....Fully illustrated, 8 p. reference includes sections on: shipping of latex; storage of latex; transfer of latex; etc. Request "Storage and Handling of Synthetic Latex," Ref. No. 55-264.
428C Goodyear Tire & Rubber Co.

Lifts, Hydraulic.....Illustrates and describes new line of multi-purpose, manually propelled, hand and battery-powered hydraulic lifts with capacities from 500 to 2000 pounds. Covers features and specifications.
428D Oster Mfg. Co.

Loaders, Truck.....Depicts operations where man-equipment hours may be saved with Lodal . . . the multi-purpose hydraulic truck loader. 3-thousand pounds capacity — loads one truck or many. Features and specifications.
428E Lodal, Inc.

Loading Assemblies.....Features: compactness, convenience, fast delivery, smooth operation, long service life & minimum pressure drop. Details on spring-balanced & counter-balanced assemblies in Catalog F-7.
162 *OPW Corp.

Now turn to the back . . .

Simply circle the code numbers desired on the handy pre-paid postcard, and mail it to us. Replies will reach you direct from the companies manufacturing the products.

* From advertisement, this issue.



'scuse us
for being chesty, but...

... we just can't help crowing about reader-response to CE's *Annual Inventory Issue.*

A chemical engineer from Brooklyn calls it . . . *"invaluable already, and without precedent."* A South Carolina plant manager stopped in to tell us . . . *"Yo'all done yo'self real proud."* A Dallas man swears . . . *"the editor musta come from Texas."*

Others went into greater detail—on content, arrangement of editorial sections, Reader Service—even the quality of the advertising. Comments and opinions were all over the lot. And they're still coming in.

What do you say? It's your magaziné and we're wide open for suggestions. We'd like your ideas . . . for the *1956 Annual Inventory Issue* of CHEMICAL ENGINEERING.

ANNUAL INVENTORY ISSUE

Chemical Engineering

A McGraw-Hill Publication, 330 W. 42nd St., New York 36, N. Y.

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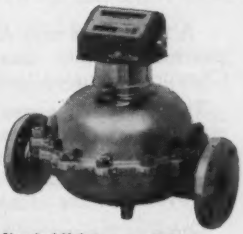


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NIAGARA *Automatic Displacement Meters!*

SET FOR 175 gallons—GET 175 gallons

Uniformity of a liquid product depends on accurate measurement of all ingredients from batch to batch. You can be sure of consistent accuracy by equipping with Niagara Electri-contact Meters. A precision electric Switch closes or opens an electric circuit after the passage of a predetermined quantity of liquid through the meter. Can also be used to generate electrical impulses to actuate other control mechanisms . . . shut off a pump motor . . . signal visually or audibly to the operator. Brings automation to liquid control and measurement in hazardous or non-hazardous atmospheres.



Chemical Meter with inclined register.



Rear View. Explosion Proof Meter.

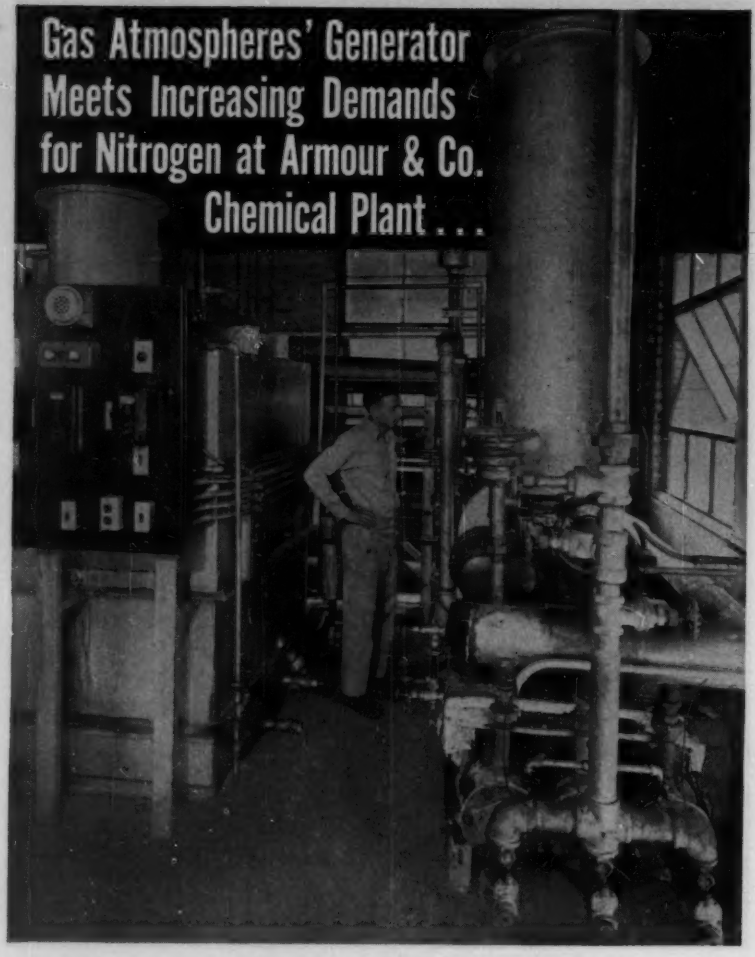
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Gas Atmospheres' Generator Meets Increasing Demands for Nitrogen at Armour & Co. Chemical Plant . . .



EXPANSION, NEW USES SATISFIED BY ADDING STORAGE FACILITIES

A few years ago Armour & Co. purchased a Gas Atmospheres' Nitrogen Gas Generator for use in their McCook Chemical Division installation. Today they're glad they did.

The reason: the use of nitrogen gas has been on the constant increase and the Gas Atmospheres' unit has met these greater needs unfailingly. Because of variable demand, they're now considering adding storage facilities in order to get even greater utilization from the units.

Some of the many Armour uses: flushing thousands of feet of lines where steam or air would introduce water or oxygen into the product; blanketing acetone; purging hydrogen gas production unit; for the gaseous element in manometer operation.

Armour engineers working with the unit, which is equipped with both refrigerant and chemical dryers, say it is a most dependable piece of equipment.

If you want long-term results like these, it will pay you to talk today with a Gas Atmospheres' engineer.

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10011 WEST LAKE ROAD CLEVELAND 16, OHIO

LITERATURE . . .

Magnets.....Presents the all-new Dings Dynamic Perma-Plate Magnets . . . for efficient—low cost tramp iron removal. Describes the numerous features and advantages of versatile magnets in Catalog No. 1205-D.
305 *Dings Magnetic Separator Co.

Materials Handling.....When time is important in handling dry materials in bulk . . . rely on Fuller systems (Fuller Kinyon Airveyor, Airslide, Fuller-Fluxo). Data in "How To Pull Dollars Out of Thin Air."
50 *Fuller Co.

Materials Handling, Bulk-Flo.....Equipment designed to reduce handling costs on wide range of materials. Features ability to feed, convey, elevate in one compact, fully enclosed assembly. 28 p. Book 2475.
13 *Link-Belt Co.

Pulleys, Magnetic.....Features: pulling power, no operating expense, operates anywhere, & the belt stays put. For tramp iron removal, you get protection for your plant & product. Request Bulletin No. 350C-1.
72 *Stearns Magnetic.

Toggle Stands, Conveyor.....Versatility and efficiency have been increased by the addition of toggle stands to two models of the aluminum Stevedore, Jr. Power Conveyor. Information and product literature on request.
430A Rapids-Standard Co.

Tractor-Loaders.....TL-6 Tracto-Loader features a short turning radius & combines a tip-back bucket with hydraulic torque converter drive & clutch-type transmission. Illustrated features & specifications.
95 Tractomotive Corp.

Tractor-Shovels.....The HA "Payloader" & the larger model HAH do the work of 4 previous units. Ideal for any bulk materials you have to scoop-up, carry, load, dump, stockpile or spread. Request data.
163 *Frank G. Hough.

Trucks, Fork Lift.....Trac-Lift 50 speeds lifting, transporting & stacking of heavy, bulky materials. Handles loads up to 5000 lbs. Operates over smooth or rough, paved or unpaved areas. Request full product information.
430B Piper & Paine.

Trucks, Hand.....The Lite-N-Tuff hand truck is specially designed to reduce effects of load jar on fragile cargo when moving over rough ground, jumping curbs, etc. Features pneumatic tires. Makes available data.
430C Hamilton Caster & Mfg. Co.

Trucks, Platform.....Thoroughly illustrated folder features the Model PO-40 . . . a walking type, battery-powered unit designed to speed the moving and stacking of skids, box tops, cases, crates, etc. Bulletin 551-3.
430D Barrett-Cravens Co.

Trucks, Straddle.....Offers a straddle type tiering truck in 4000 lb. capacity. Increased capacity made possible by adoption of a heavy duty frame, tandem load wheels, special thermal controller motors, etc. Bulletin 831.
430E Raymond Corp.

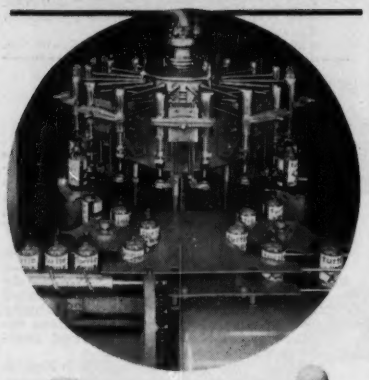
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Rotavac





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for fast no-drip filling!

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PNEUMATIC SCALE CORP., LTD., 85 Newport Ave., Quincy 71, Mass. Also: *New York; Chicago; Dallas; San Francisco; Los Angeles; Seattle; Leeds, England. Canadian Division: Delamere & Williams Company, Ltd., Toronto.*

PNEUMATIC

Packaging and Bottling Equipment

Pumping Progress Report

FOR CHEMICAL ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

PUMP INSPECTION, MAINTENANCE AND REPAIR are jobs too frequently ignored in the design of production pumps. This has been verified by a survey of more than 15,000 pump installations. Speed and economy of maintenance was frequently quoted as a major factor in pump selection.

SECTIONALIZED FLUID-ENDS offer one of the best ways to guarantee both speed and economy in pump maintenance. As originated by ALDRICH Pump Co. Engineers, the Sectionalized Fluid-End comprises four main assemblies — the working barrel, suction manifold, discharge manifold and stuffing box.

SPEED IN MAINTENANCE is assured because of ease of accessibility of all wearing parts. Manifolds can be slid back on studs and valves removed as complete units. Split collar and flange connection of plunger to yoke permits easy removal of plunger.

ECONOMY OF MAINTENANCE results from speed in maintenance. Perhaps even more important is the simple fact that it is cheaper to replace a single section than a complete fluid-end. Another important economy is parts interchangeability. Among 3-, 5-, 7- and 9-plunger units of any series, wearing parts are interchangeable. Where a combination of multiplex pumps is required, this reduces spare parts stocks.

THE ALDRICH PUMP COMPANY is the originator of the DIRECT FLOW principle — a design innovation that utilizes the sectionalized fluid-end principle. Aldrich Engineers have become known as the people to take your tough pumping problems to. We have never turned down a challenge.

FURTHER INFORMATION can be had direct from the company. Tell us your problem and we'll send you Data Sheets describing the size pump we recommend to solve your problem. Address your request to: The Aldrich Pump Company, 3 Gordon Street, Allentown, Pa.

Ask Standard how to cut costs with conveyors



Live roller and gravity roller system handles 55 gal. drums from storage through filling and weighing operations to shipping.

No manpower needed to keep heavy drums moving

STANDARD conveyor systems keep heavy, bulky commodities moving with minimum manpower and time loss. Systems can be job-tailored to any specific materials handling problem — to meet almost any needs.

With more than 50 years of experience in conveyor application, Standard engineers are qualified and ready to help solve your handling problems. Standard builds permanent or portable systems and units, using roller, belt, slat, chain, push-bar or sectional conveyors — power or gravity; also spiral chutes and pneumatic tube systems. Consult STANDARD CONVEYOR COMPANY General Offices: North St. Paul 9, Minnesota. Sales and Service in principal cities.



Cut costs, too, in shipping and receiving operations with Standard portable units, either powered or gravity operated. (Left) HANDIBELT portable powered conveyor unit (right) LITEWATE Sectional Roller Conveyor.



Call the Standard engineer listed in your classified phone book, or write direct for Bulletin 309 — address Dept O-3

Standard 50 years of conveyor experience

GRAVITY & POWER CONVEYORS

Sales and Service in Principal Cities.

LITERATURE . . .

Weighing Systems.....Supply basic data for your accounting system. Records that originate at scales directly affect costs, inventories & customer billings. For complete details request, Bulletin 2036.
439 *Toledo Scale Co.

Heating & Cooling

Boilers, Packaged Automatic.....Offer valuable features: low-cost, space saving installation; fast steaming; instant response to load changes; quick fuel change-overs; clean, dry steam; etc. Data in Bulletin 1220.
89 *Orr & Sembower.

Burners, High Velocity.....Completely separate from the liquid being heated & maintenance, control & accessibility are greatly simplified. High heat release rate in these submerged combustion units. Bul. 110.
436 *Thermal Research & Engrg.

Coolers, Rotary Air.....Company furnishes complete information on the Davenport rotary air cooler (6'0' dia. x 80'0' long). Cooler is of aluminum construction to cool molten alum. Request Catalog "A."
BL329 *Davenport Mach. & Foundry

Generators, Steam.....Illustrated, 14 p. describes Titusville Type WTP shop-assembled Water Tube Steam Generators. Includes technical data, a dimensional drawing with table of dimensions, etc. Bulletin 5511.
432A Struthers Wells Corp.

Generators, Steam.....16 p. book gives capacities, dimensions, construction features, instrumentation, accessories, sectional drawings & installation photos on new series of steam generators. Bulletin PG-55-3.
241 *Foster Wheeler Corp.

Heat Exchangers.....The Rietz Thermascrew is basically a true heat exchanger consisting of a hollow screw mounted on a hollow shaft, rotating at slow speeds in a jacketed trough or pipe. Details in Bulletin No. T-506.
432B Rietz Mfg. Co.

Heat Exchangers.....Exchangers for refineries, petrochemical plants & for chemical plants are available at Western. Request a copy of the company's new booklet, "Brand of Progress" for details.
71 *Western Supply Co.

Heat Exchangers.....Aero heat exchanger cools liquids & gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. Data in Bulletins 120.
434 *Niagara Blower Co.

Heat Exchangers.....In De Laval plate heat exchangers the plates are so designed as to produce strong turbulence and high velocity . . . achieving maximum heat transfer. Plate Heat Exchanger Bulletin PHX.
223 *De Laval Separator Co.

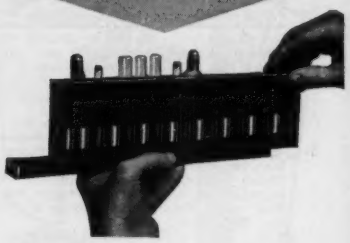
Heat Transfer Apparatus.....Votafor heat transfer apparatus can improve efficiency and product quality in numerous processes. Company makes available a Heat Transfer Data Book containing complete information.
2 *Girdler Co.

Heat Transfer Equipment.....Announces the availability of a new reference which provides dimensions, data and capacities for easy selection of the more commonly used types of heat transfer equipment. 12 p. Bulletin 31.
432C Buxton Mfg. Co.

Heating Systems, Dowtherm.....Furnishes descriptive information on Dowtherm heating systems for processes requiring precision control of high constant temperatures at low pressures, in Bulletin ID-54-5.
131 *Foster Wheeler Corp.

* From advertisement, this issue.

ACCURATE
pH, CHLORINE
CONTROL
with
TAYLOR COMPARATORS
REDUCES WASTE



Helps determine EXACT amounts of chemicals needed for adjustments

Fast, accurate colorimetric analyses, with Taylor Comparators, make it easy to determine the *exact* amounts of chemicals needed to control many chemical processes. Colorimetric tests with Taylor Comparators may be made on the spot in only a few minutes. Simply fill the three test tubes with the solution to be tested, add reagent to center tube and move color standard slide across until colors match.

Taylor Comparators are durable, lightweight and portable; many serve for several determinations with only a change of color standard slides.

COLOR STANDARDS GUARANTEED

Taylor liquid color standards carry an unlimited guarantee against fading. There's no danger of mechanical inaccuracy. Each complete set of standards is mounted in a lightweight, durable plastic slide . . . no single standards to handle.

CALL YOUR LABORATORY SUPPLY HOUSE for Taylor sets, or write direct for FREE HANDBOOK, "Modern pH and Chlorine Control". Gives theory and application of pH control, illustrates and describes full Taylor line.



W. A. TAYLOR AND CO.
414 RODGERS FORGE RD. • BALTIMORE, MD

Pump Maker Reports:



This high pressure pump is one of a complete line of Philadelphia pumps designed in capacities from 2cc to 15,000 gph.

Garlock Teflon packings, CHEVRON packings, and Garlock gaskets such as these assure uninterrupted service of Philadelphia pumps.

"GARLOCK *has the answer for ALL our packing and gasketing problems*"

Since its early years, the Philadelphia Pump and Machinery Company, has standardized on Garlock packings and gaskets for its 863 different models of controlled capacity pumps for pressures up to 50,000 psi. The reasons are simple:

1. Only Garlock makes a *complete* line, therefore only Garlock can take complete responsibility for all packing and gasketing problems on all Philadelphia pumps.

2. Garlock's engineering service is unduplicated in the industry. (Every one of Garlock's 125 salesmen is a trained packing expert.) In addition, Garlock maintains an Engineering Service Department staffed with specialists in every phase of packing and gasketing.

Prove for yourself that Garlock has the answer for every packing and gasketing problem. Call your local Garlock representative.

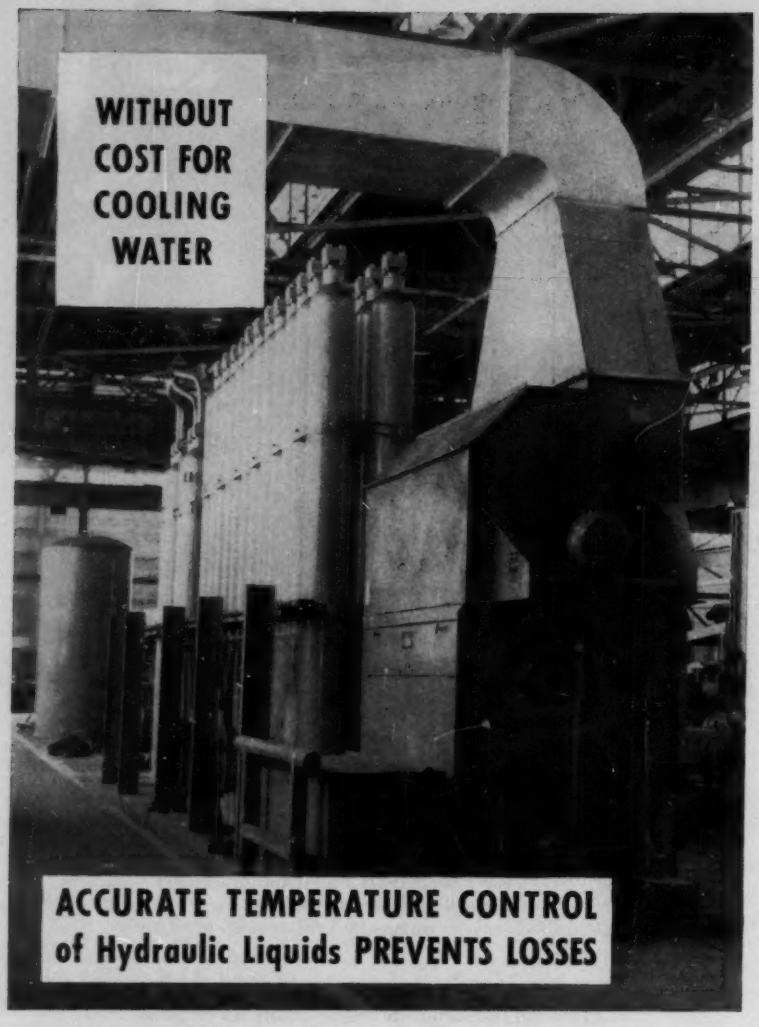
THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N.Y.), Philadelphia, Pittsburgh, Portland (Ore.), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK

PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS



● This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

Air is free and cheaper to move than water. You can save much expense in pumping, piping and power, and quickly recover the equipment cost from the water saving.

Similar Niagara machines cool water, oils, solutions, lubricants and coolants for many mechanical, electrical and chemical processes. You can cool quench baths, welding machines, plastic molds, furnaces, controlled atmospheres, gases, compressed air either for power or instruments or processes. In a closed system, your coolant is never contaminated. The system is simple and easy to keep up; the equipment has a long, useful life. Select from a wide range of sizes up to 30,000,000 BTU.

Write for Bulletin 120 to obtain a complete description.

NIAGARA BLOWER COMPANY

Dept. CE, 405 Lexington Ave. New York 17, N. Y.

Niagara District Engineers in Principal Cities of United States and Canada

LITERATURE . . .

Preheaters, Air.....The Ljungstrom boosts product quality & its heat-recovery efficiency makes possible advanced furnace designs that assure close control of processing. For information, request product data.
16 *Air Preheater Corp.

Thermo-Panels.....Cost less & perform better—an improvement on pipe coils. You save space & heat or cool more efficiently. For use in heating & cooling of liquids, slurries, soaps, etc. Bulletins 355 & 256.
TR448 *Thermo-Panel Div.

Towers, Cooling.....Pritchard Cooling Tower framework is a big step in cooling tower design. "Answers to the 15 Questions About Pritchard Induced Draft Cooling Towers" furnishes valuable tips.
318-9 *J. F. Pritchard & Co.

Traps, Steam.....Impulse steam traps offer valuable features: get equipment hot in a hurry—& keep it hot; good for all pressures without change of valve or seat; easy installation; etc. Request Trap Bulletin.
235 *Yarnall-Waring Co.

Traps, Steam.....Give faster, more effective condensate removal. Powerful valve action, positive shut-off, high capacity & each unit service tested. For more details, request new Bulletin No. 10-55.
278 *W. H. Nicholson & Co.

Traps, Steam.....Machined from a solid block of stainless steel, this trap has only 3 parts . . . cap, disc, & body . . . no valve-closing mechanisms. Only moving part is a solid steel disc. Bulletin No. 257.
209 *Sarco Co.

Instruments & Controls

Actuators, Valve.....Makes remote electrical operation of the final control element a reality for the first time. For information on how "EHVA" control is adapted, request your copy of Bulletin No. 200.
423 *Askania Regulator Co.

Analyzers & Recorders.....Chart final yield and H_2-N_2 ratio before and after recycle gas enters feed stream. L&N Analyzers have been proven successful throughout the process industries. Folder ND46-91(2).
38 *Leeds & Northrup Co.

Annunciators.....The "VS" annunciator identifies first off-normal condition, enabling the operator to take immediate, corrective action. The "50VS" is completely flexible. Request complete literature.
17 *Panellit, Inc.

Comparators.....Fully illustrated, 100 p. tells how to use pH and chlorine control for water supplies, process solutions, production processes in 34 basic industries. Also covers complete line of comparators.
L433 *W. A. Taylor & Co.

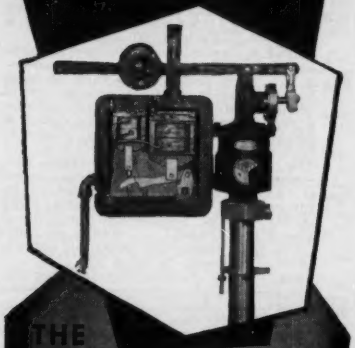
Controls, Air Pollution.....The Bendix-Friez Aerovane system can be a big help to you in offsetting air pollution problems. The entire system can be used in dozens of plant applications. Details are available.
R415 *Friez Instrument Div.

Controls, Temperature.....United Electric designs units to automatically control temperatures of gases, liquids, etc. where there are explosive vapors. Request Bulletin No. 3-1 for the D98 & Bulletin No. 3-5 for the E98.
441 *United Electric Controls Co.

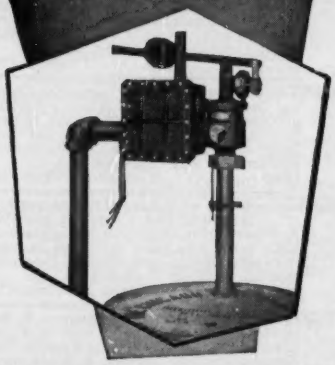
Controls, Temperature.....Features: cuts initial control costs; costly production stoppages; control maintenance costs. Controls for gas, liquids & solids in −30° to 1200°F. ranges. Condensed Catalog CC.
413 *Partlow Corp.

* From advertisement, this issue.

A NEW
AUTOMATIC VALVE
TO SOLVE YOUR TANK OR DRUM FILLING PROBLEMS



THE
DAVIS
o. 97TH SOLENOID VALVE
SAVES TIME
AVOIDS WASTE
PROMOTES SAFETY



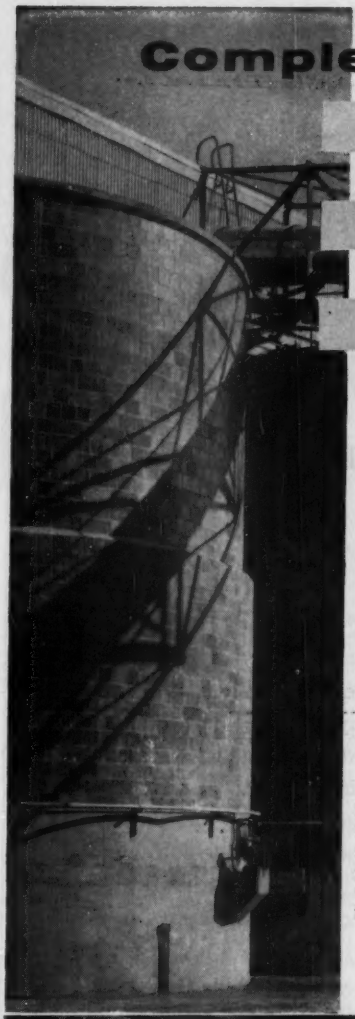
Here is the solution to your container filling problems. It is the DAVIS two-step solenoid valve especially designed for accurate weighing and filling. No more guesswork, no more spillage, no more waste. You get faster filling that always keeps step with production. This valve is ruggedly built to withstand years of hard service. Standard or explosion-proof housing available. No matter what liquids you are handling DAVIS can meet your need, giving you the most efficient, economical operation possible.

Here is a valve you can sell to many different industries. Solvents, chemicals, additives, petroleum products, and many others have filling problems. Write for complete details today.



DAVIS REGULATOR COMPANY

2544 South Washtenau • Chicago 8, Illinois



Complete Service

DESIGN
by our own engineering staff

INSTALLATION
by our own construction crews

MAINTENANCE
by our own service specialists

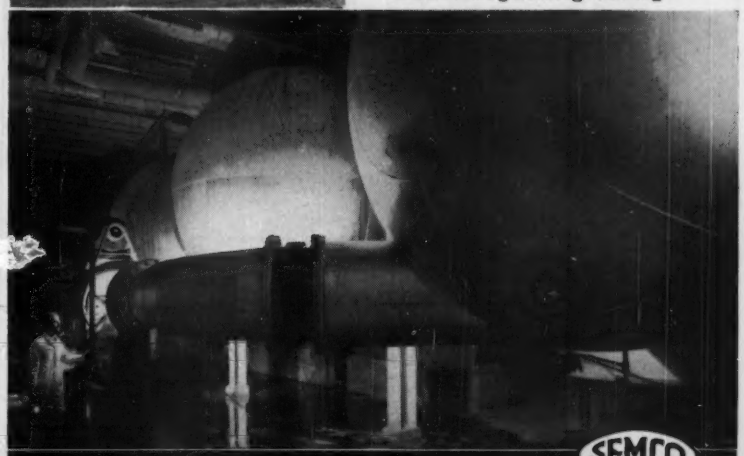
of Non-Metalic Corrosion-Resistant
LININGS and TILE TANKS

Designed and installed to meet the exact chemical and physical requirements of each installation, Stebbins linings and tile tanks are industry-famous for their efficiency and economy.

Wherever you are—whatever your corrosion-resistance problem may be (even at high temperature and high pressure)—it will pay you to take advantage of Stebbins' unequalled design experience and installation facilities.

Write for Bulletin A-153

See our Advertisement in Chemical Engineering Catalog



SEMCO

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Engineering and Manufacturing Company, Watertown, N. Y.

STEBBINS ENGINEERING CORP. – 1504 TOWER BLDG., SEATTLE, WASH.
CANADIAN STEBBINS ENGR. & MFG. CO., LTD. – CASTLE BLDG., MONTREAL, CANADA

SINCE 1884
Specialists in Design, Installation and Servicing of Linings and Tile Tanks

TANTALUM... We recommend it only when it is the cheapest material AVAILABLE

Tantalum is seldom cheaper on a "per-pound" basis. But tantalum is quite often the "cheapest" material when judged on an over-all final operating cost basis, on a product purity basis, on a freedom from maintenance or an elimination of down-time basis.

We don't expect anyone to take tantalum on faith or generalities. But if you process hydrochloric acid, nitric acid, perchloric acid, bromine, iodine, hydrogen peroxide, sulfuric acid, chlorine, chlorine dioxide (and many other corrosives), tantalum may save you money. Fansteel engineers can tell you, definitely, whether or not tantalum will be "cheapest" for you.

USE TANTALUM WITH ECONOMY for most acid solutions and corrosive gases or vapors, except HF, strong alkalis or substances containing free SO_3.



Write for free book, TANTALUM in Chemistry

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U.S.A.

G563A

LITERATURE . . .

Detectors, Leak.....Beckman Bulletin features their new Leak Detector . . . designed expressly to detect, locate, and measure minute leaks in evacuated, pressurized or hermetically sealed equipment. Bulletin No. 17.
436A Beckman Instruments.

Detectors, Temperature.....The Radiamatic unit is a radiation detector used with an ElectroniK instrument to measure, indicate, record and/or control temperature. For complete information, request Catalog No. 9301.
436B Minneapolis-Honeywell.

Electromanometers.....CEC's electromanometer reads out in direct numerical form. It equals manometer-tube accuracy. For more information on pressure measurement, request a copy of Bulletin CEC 1547-X13.
BL321 *Consolidated Electrodynamics.

Gages.....For pressure, vacuum or compound service. There are no gears or teeth to wear out. Cam wiping action keeps contact points clean & smooth. Provides complete information in Gage Catalog No. G-2.
314 *Helicoid Gage Div.

Gages, Liquid Level.....Completely illustrated 76 p. reference describes the entire line of Penberthy liquid level and water gages . . . and also indicates their numerous points of superiority. Request Catalog 35.
152a *Penberthy Injector Co.

Indicators.....Makes available a convenient reference for those interested in panel and portable indicators for measurement of temperature, electrolytic conductivity and pH. For your copy, request Catalog No. ND42.
436C Leeds & Northrup Co.

Indicators, Temperature.....Model F-1 is available with maximum visibility dial; choice of temperature ranges from minus 60°F to plus 750°F; etc. Request catalog describing line of indicators & recorders.
T322 *Electric Auto-Lite Co.

Instrumentation.....Dynalog instruments can be used with resistance, voltage, capacity, or inductive type primary elements to measure &/or control any process variable with speed accuracy. Bulletin No. 343.
27 *Foxboro Co.

Instrumentation.....F&P General Catalog describes product line: complete process instrumentation; data reduction & automation systems; centralized control stations; chlorination equipment; etc. Catalog No. 1.
436D Fischer & Porter Co.

Instrumentation of Rotary Kiln Operations.....describes improvements possible in rotary kiln operation by automatic L&N control of such variables as temperature, draft, and speed. Information in Catalog N-00-664(1).
436E Leeds & Northrup Co.

Instruments, Test.....Illustrates & describes the entire line of Precision test instruments for industrial & radio-TV-communications service & other electrical & laboratory applications. Catalog No. 23.
436F Precision Apparatus Co.

Meters.....Describes the Alnor Velometer—a precision-built, self-contained, portable instrument which gives instant, accurate readings of air velocities anywhere. Full details in Bulletin No. 2448-G.
R329 *Illinois Testing Labs.

Meters, Electricontact.....Now—explosion-proof—a new Niagara electricontact meter . . . for automatically measuring and controlling liquids in hazardous atmospheres. Complete details in Bulletin No. 35.
R429 *Buffalo Meter Co.

Photometers, Flame.....Furnishes information on the Model 41 Direct-Reading Flame Photometer . . . a new instrument for sodium and potassium determinations in clinical and industrial laboratories. Bulletin No. 396.
436G Beckman Instruments.

* From advertisement, this issue.

Potentiometers, Transmitting.....Measure & control thermocouple temperatures or the signal from such devices as pH amplifiers, gas analyzers, etc. High accuracy in process temperatures control. Bulletin MTTS10.
28 *Manning, Maxwell & Moore.

Pyrometers, Millivoltmeter.....Describes Protect-O-Vane Excess Temperature Cut-Off (Type No. 105). Non-recording instrument. Combines high-resistance measuring system with vane type electric control. Catalog No. 1053.
437A Minneapolis-Honeywell.

Recorders.....Offer valuable features: pre-calibrated plug-in receiver units; up to 4 pneumatic or electronic receivers—or 2 receivers & 2 integrators; etc. Product Spec. E12-5 & actual chart sample on request.
280 *Bailey Meter Co.

Rectifiers.....Illustrates & describes standard models of Sel-Rex Germanium Rectifiers from 50 to 50,000 amperes capacity, in either forced air or completely sealed water cooled design. Request Reference No. GR3105.
437B Bart-Messing Corp.

Scanning & Logging Systems.....Fully illustrated, 14 p. brochure describes the Taylor "Trans Scan Log" control system. Permits quick identification, evaluation & correction of any process change. Bulletin 98268.
437C Taylor Instruments Cos.

Snubbers.....Stops noise from intake & exhaust of air, etc. & stops pulsation caused by line surges from compressors, pumps, & blowers. Company makes available literature on its line of pulsation snubbers.
TR306 *Burgess-Manning Co.

Spectrophotometers.....Announces the availability of a 12 p., fully illustrated brochure on the Ratio-Recording DK-2 Spectrophotometer with curves, performance characteristics, etc. Request Bulletin No. 377.
437D Beckman Instruments.

Thermometers.....Fully describes Circular Case Thermometers and Hygrometers (Type No. 612). Actuation—for relative humidity: hair hygrometer; for temperature: mercury-filled thermal system. Bulletin No. 6504.
437E Minneapolis-Honeywell.

Thermometers.....Features: can be installed anywhere; Maxivision dial guarantees accurate reading, & bimetal actuation insures high sensitivity, economy & surety of operation. Request Bulletin 148.
156 *Manning, Maxwell & Moore.

Transmitters, Pneumatic.....36 p., reference covers transmitters for measuring flow, pressure, level or density. Describe & illustrates 22 different models, gives hook-ups, ranges, performance data. Data Book 1004.
57 *Republic Flow Meters Co.

Transmitters, Potentiometer.....Adaptable for the measurement of a wide variety of variables, & can be quickly modified for use with different electrical primary elements. Request Bulletin No. 98262.
84 *Taylor Instrument Cos.

Keeping too busy?

You'll find our streamlined Reader Service section right up your alley. It's designed for busy engineers who want to find things fast, get more information fast. RS is easy to use, and you can bank on it.

* From advertisement, this issue.



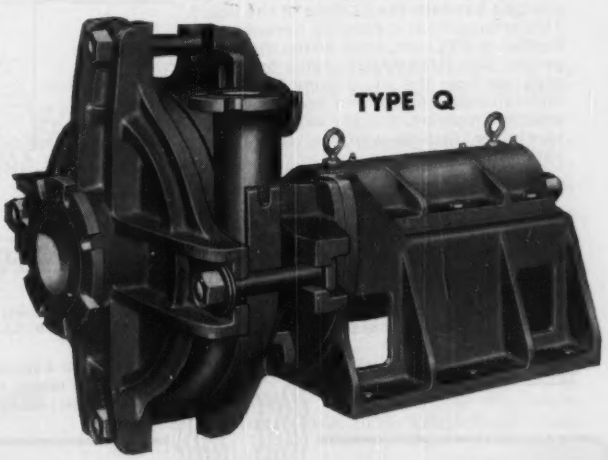
misfits cost money...

Coddling old pumps, "bargain" pumps or pumps that weren't engineered for the job can be an expensive proposition.

When misfits like this are put to work, they generally can handle only half the job they should. Often their "downtime" is greater than their operating time. And when pumps fail the greatest cost is not for repairs—but for lost production.

Start today by replacing "misfits" with new Morris pumps. For nearly a century Morris has been manufacturing a complete line of top quality pumps to meet the diversified requirements of industry. Every Morris pump has been specially designed and engineered to handle a specific job and to give you years of trouble-free service under the most rugged conditions.

Specify Morris when you want lasting pump value . . . it will save you money in the long run.



MORRIS CENTRIFUGAL PUMPS

● **Free Service.** Morris Engineers will be glad to recommend the pump best suited to your needs for size, capacity, etc. Send necessary data today to Morris Machine Works, Baldwinsville, N. Y.

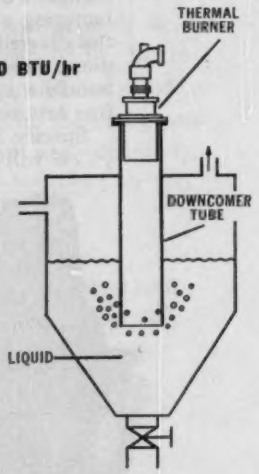
THERMAL
SUBMERGED
COMBUSTION



simplicity of design and construction... *plus* extreme compactness

HEAT INPUTS OF 250,000 BTU/hr to 5,000,000 BTU/hr

The high heat release rate of the THERMAL High Velocity burner used in these submerged combustion installations allows the use of a simple downcomer tube through which the products of combustion are discharged beneath the surface of the liquid. This arrangement is possible because combustion is 90% completed within the burner proper. The THERMAL burner is completely separate from the liquid being heated and maintenance, control and accessibility are greatly simplified. Equally simple arrangements are possible with gas, oil or combination fuel.



BROAD RANGE OF APPLICATIONS

Depending upon the material being heated either a metal or refractory downcomer tube may be used. Some of the more common applications are pickling baths, acid concentration, caustic soda concentration, aluminum sulphate concentration, water recarbonization, and glass frit and molten salt heating.

WRITE FOR BULLETIN #110

OTHER THERMAL PRODUCTS & SERVICES → **Gas, Oil & Combination Burners • Air Heaters • Combustion & Heat Transfer Equipment**

THERMAL
Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

LITERATURE . . .

Pipe, Fittings, Valves

Fittings, Forged Steel.....Wherever strong, tough pipe joints are needed . . . Watson Stillman forged steel fittings provide a safety factor against costly piping failures. Details in Bulletin No. A3-50.
315 *Watson-Stillman Fittings.

Fittings, Pipe.....Presents newest catalogue of stainless steel pipe fittings which shows all standard pipe fittings and flanges, flanged fittings, butt weld fittings, etc. Request fully illustrated Catalog No. 653.
299a *Camco Products

Fittings, Stainless Steel.....Speedline fittings simplify pipeline design. Details of the greater design flexibility possible with Speedline fittings . . . at lower cost . . . in new fully illustrated catalog.
BL333 *Horace T. Potts Co.

Fittings, Welding.....Weldolet welding fittings serve the nation's industries. There are branch connections for any and all piping services. Company offers a catalog describing their line. Catalog No. W-4.
326 *Bonney Forge & Tool Wks.

Fittings, Wrought Iron.....Fibres of inert iron silicate distributed throughout high-purity iron make this piping material desirable for applications where corrosion is a factor. Bulletin No. TT-787.
35-6 *Tube Turns.

Flange Specifications.....Company announces the development of a new Flange Specification table for ASA and MSS Flanges in a convenient, slide rule form. Pocket-size reference is available upon request.
299b *Camco Products.

Pipe, Polyvinyl Chloride.....This high quality unplasticized-rigid pipe is available in two types: normal-impact and high-impact. Polyvinyl chloride is the best for plastic pipe. Request Bulletin 24.
94 *U. S. Steel Corp.

Valves.....The type D pressure reducing & regulating valve has half the number of bolts which saves maintenance time. Gasket seal at diaphragm flange provides easier pressure range conversion. Bulletin 950.
253 *A. W. Cash Co.

Valves.....By an exclusive method, hard facing alloys are welded to the integral seat of globe & angle valve bodies & to the removable steel seat rings of gate valves. Catalog describes complete line.
164 *Henry Vogt Machine Co.

Valves, Control.....Announces new standard line of control valves—S-3000 Series. Valves represent first basic departure in control valve design & overcome all present day limitations. Details in Bulletin No. 101-C.
438A Hammel-Dahl Co.

Valves, Diaphragm.....From antibiotics to the toughest acids, alkalis and salts, there is a combination of Hills-McCanna body and diaphragm materials that will best suit your needs. Request Valve Catalog.
25 *Hills-McCanna Co.

Now turn to the back . . .

Simply circle the code numbers desired on the handy pre-paid postcard, and mail it to us. Replies will reach you direct from the companies manufacturing the products.

Valves, Explosive.....New reference illustrates and describes the complete line of Conax Explosive Valves. Entire operation shown including the "normally closed" and "normally open" valves. Request Catalog No. 5501-XV.
439A Conax Corp.

Valves, Gate.....For pressures up to 150 lbs. & temperatures to 180° use iron body gate valves with permanently bonded hard rubber lining. Available in rising stem, cylinder or motor operated, or quick-opening types.
308 *Darling Valve & Mfg. Co.

Valves, Safety Relief.....Features: economical "2 in 1" design, peak performance, absolute protection, & maximum interchangeability. Full range of sizes & pressures available. Request Catalog No. 1900.
88 *Manning, Maxwell & Moore.

Process Equipment

Agitating Equipment.....Use Nettco Flomix to combine liquids & solids as they flow through a pipe line. For complete information, company makes available bulletins & data. Nos. 531, 551 & 532.
24 *New England Tank & Tower.

Blenders, Twin Shell.....In plant after plant . . . the Patterson-Kelley twin shell blender does the job better, faster, and lasts longer. For complete information on product line request descriptive Catalog 13.
56 *Patterson-Kelley Co.

Centrifugals.....When your process calls for liquid-solids separation by centrifugal force . . . you can do it more economically with the new Tolhurst Center-Slug centrifugal. Request descriptive Catalog.
407 *American Mach. & Metals.

Centrifuges.....Provides industry with 7 types of continuous centrifuges to handle materials ranging from 2 immiscible liquids to crystalline solids. Briefly & geographically describes full line in Bulletin No. 1259.
137 *Sharples Corp.

Classifiers, Air.....The Hardinge Gyrotor Classifier system, combined with a Hardinge grinding mill is an integrated grinding, classifying & product conveying system. Details in Bulletin No. AH-467-11.
410 *Hardinge Co.

Dehydrators.....Compressed air & gas dehydrators, either manually operated or fully automatic up to pressures of 1000 psig are manufactured to customers' performance specifications. Request Bulletin No. R-11.
439B Desomatic Products.

Dispersers, Sub-Micron.....Profusely-illustrated booklet describes the Gaulin Sub-Micron Disperser . . . for pigment dispersions. Complete details of features, construction, operation & specifications. Bulletin SMD-55.
439C Manton-Gaulin Mfg. Co.

Dryers.....Help solve problems of drying air or other gases. Offer valuable advantages: simplicity of operation & maintenance; low installation cost & minimum maintenance expense. Details in Bulletin D-29.
29 *C. M. Kemp Mfg. Co.

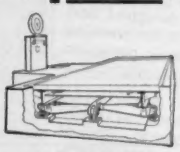
Dryers.....For solids drying . . . mechanical McNally Dryclone separates at low cost. Here is high drying efficiency, with drying costs held to a few cents per ton. Request descriptive drying Bulletins.
312 *McNally Pittsburg Mfg. Corp.

Dryers.....Iectro-dryers can dry air & gases in volume to dewpoints below —100°F—can, drop relative humidity lower than 10%. Booklet describes machines & how various industries use them to gain efficiency.
265 *Pittsburgh Lectrodryer Corp.

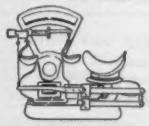
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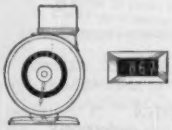
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A MODERN WEIGHING SYSTEM can make a big difference in cost control and profit in your plant!

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If you would like to look further into this in your plant, why not drop us a line today? No obligation, of course. Ask for Booklet 2036. Toledo Scale Company, Toledo 1, Ohio.

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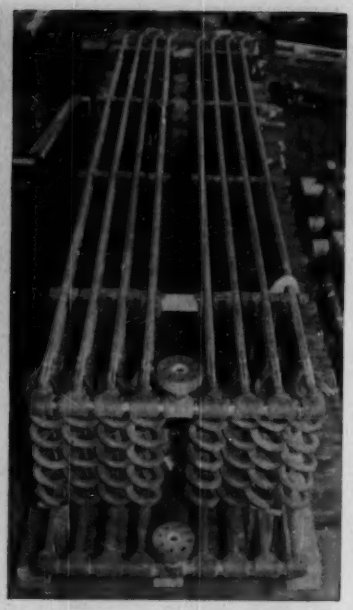


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HEADQUARTERS FOR SCALES



In the manufacture of ammonia, nitrogen and hydrogen are combined under heat and pressure with a catalyst and the resultant ammonia gas is then cooled in this Vilter ammonia synthesis cooler.



This Vilter unit was designed to operate at a working pressure of 10,000 lbs. psi. Bend in the tubing is off the vertical plane to permit easy flow of the gas in the cooler.

Q. Why do ammonia manufacturers use Vilter synthesis condensers?

A... because Vilter special heat exchangers

cost less to own*

Not only cooling, but cooling under intense pressure, are the challenging aspects of designing and fabricating synthesis condensers used in the manufacture of ammonia. A tough job, yes . . . but at Vilter this problem is successfully resolved through the experience of having designed and produced thousands of heat exchangers and pressure vessels to exacting specifications for almost every type of application . . . working pressures as high as 10,000 psi. Of course, pressure vessels are built in conformance to A.S.M.E. and A.P.I. standards.

During the past few years, Vilter has supplied vessels to such nationally known companies as Shell Chemical, Esso Standard, Monsanto, Phillips Petroleum, American Cyanimid, Continental Oil among many others. These companies have learned that Vilter can give them what they want at the right price.

Vilter makes all four basic types of heat exchangers: shell and coil, shell and tube, shell and tube bundle, and atmospheric . . . and in every possible modification. Vilter can give you the most efficient heat exchange equipment required for a specific purpose. Consult with Vilter, today.

* Savings in low first cost are not the complete answer when considering the installation of heat exchange equipment. But savings in terms of years of extra service, reliable performance and minimum maintenance—that's where Vilter excels in low-cost ownership.

QUALITY CRAFTSMANSHIP that lasts...

ENGINEERING DESIGN that guarantees performance

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REFRIGERATION and AIR CONDITIONING

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Air Units • Ammonia & Freon Compressors • Booster Compressors • Baudelot Coolers • Water & Brine Coolers • Blast Freezers • Evaporative & Shell & Tube Condensers • Pipe Coils • Valves & Fittings • Pakice & Polarflake Ice Machines

LITERATURE . . .

Dryers, Closed Circuit.....The advantages and practical features of closed circuit drying using an inert gas for removal and recovery of an organic solvent are covered in a 4 p. illustrated reprint.
440A Wyssmont Co.

Dust Control.....Ducon Dynamic centrifugal wash collectors provide the highest efficiency obtainable in wet type collectors. The UW-3 unit reclaims valuable fines. Descriptive literature gives details.
449 *Ducon Co.

Dust Filters.....“Type RJ” dust filter is an economical, high efficiency, automatic-continuous dust filter which can be furnished for pressure or vacuum operation. For more information, request Bulletin 560.
408 *Day Co.

Ejectors, Steam-Jet.....Presents a 60 p. “Steam-Jet Ejector Application Hand-Book” for selection of single and two-stage stock ejectors for general vacuum service. Photos, tables, graphs, etc. Bulletin W-205-E21.
157 Worthington Corp.

Elbows, Reducing.....Offer important advantages in both piping design & piping cost. Need only 2 welds instead of the 3 required by a standard elbow & a reducer. For full details, request Catalog No. 54.
135 *Midwest Piping Co.

Filter Fabrics.....The right fabric adds efficiency to continuous operation. Announces availability of a fully illustrated booklet, “Filter Fabric Facts,” describing filter fabric development and application.
66 *Wellington Sears

Filter Sheets.....Complete range of stainless steel plate & frame sheet filters now available. Ideal for products ranging from ultra fine pyrogen solutions to coarse prefiltered bulk chemicals. Catalog.
TR323 *Ertel Engrg. Corp.

Filters.....Cuno's new Super Auto-Klean filter now makes possible economical, compact, micronic filtration at high flow rates & eliminates the need for replacement cartridges. Full data is available upon request.
96-7 *Cuno Engrg. Co.

Filters.....Company makes available a series of bulletins on its line of Stay-new filters for every industrial need. It also manufactures special filters to cope with unusual filtration problems. Request literature.
52a *Dollinger Corp.

Filters, Horizontal Vacuum.....Bird-Frayon continuous, rotary, horizontal vacuum filter combines: super efficient multi-stage washing; high operating efficiency; low operating cost. Bulletin No. BP-2-55-5M.
11 *Bird Mach. Co.

Filters, Tubular.....New Hydra-Shoc filter creates own air pressure for fast self-cleaning . . . small floor space; eliminates filtered water for cleaning & back flow pumps. Request special Bulletin 114-1155.
R333 *Industrial Filter & Pump.

Filtration Equipment.....Sperry makes available a catalog complete with charts, tables, & diagrams to help in the operation, maintenance & selection of filtration equipment. Request your copy. Catalog 7-E.
411b *D. R. Sperry & Co.

Generators, Inert Gas.....At a moment's notice of fire or explosion dangers, smothering gas flows instantly from R-C inert gas generators. Details on how they afford constant protection in Bulletin IGG-155.
R417 *Roots-Connersville.

Hydraulic & Air Components.....36 p. book, “Hydraulic & Air Components by Star Jack,” describes products & services. Features, specifications, & applications of pumps, cylinders, jacks, etc. Catalog No. 555.
440B Star Jack Co.

*From advertisement, this issue

Kilns, Rotary.....Efficient thermo-processing of products. Used in the production of lime, bauxite, cement, sodium silicate, alumina, etc. Complete data on design features offered in illustrated Bulletin 115.
286 *Traylor Engrg. & Mfg. Co.

Lubrication Systems.....The Farval valve has only two moving parts—is simple, sure & foolproof, without springs, ball-checks or pinhole ports. There is a "tell-tale" indicator at each bearing. Request Bulletin 26.
12 *Farval Corp.

Mixers.....Company makes available Confidential Mixing Data Sheet. Helpful checklist enables you to develop a complete technical description of agitation required for your process, quickly & easily. No. B-107.
123a *Mixing Equipment Co.

Mixers, Pony.....The exceptionally rugged, heavy duty design characteristics of the Day pony mixers enables you to mix a stiffer, heavier paste, resulting in many advantages. Details in Bulletin No. 500.
303 *J. H. Day Co.

Mixers, Portable.....Use in industry reduces costs, saves time, labor and secures better and more refined products. Catalog includes data on construction, dimensions, specifications, etc. 28 p. No. B-108.
123b *Mixing Equipment Co.

Mixers, Side Entering.....Furnishes detailed information on features, typical applications, mechanical design, maintenance, shaft seals, methods of installation, etc., in completely illustrated Catalog B-104.
123c *Mixing Equipment Co.

Mixers, Top Entering.....Illustrated and detailed 32 p. Catalog includes advantages, typical installations, mechanical description, construction information, dimensions and selection tables, etc. Catalog No. B-102.
123d *Mixing Equipment Co.

Mixers, Top Entering.....Makes available pertinent information on top-entering mixers (propeller type) . . . for closed tanks, pressure & vacuum . . . for open & loose-covered tanks. Data in Catalog No. B-103.
123e *Mixing Equipment Co.

Mixers, Steam-Water.....No. 1360 Series injects steam directly into the water, using every BTU of heat energy to bring water to a constant, predetermined temperature. Descriptive literature upon request.
151a *Fulton Sylphon Div.

Mixers, Water, Hot-Cold.....Descriptive literature on new hot-cold water mixers. No. 1350 Series Mixers give an accurate, controlled source of tempered water. Unaffected by variations in water pressure.
151b *Fulton Sylphon Div.

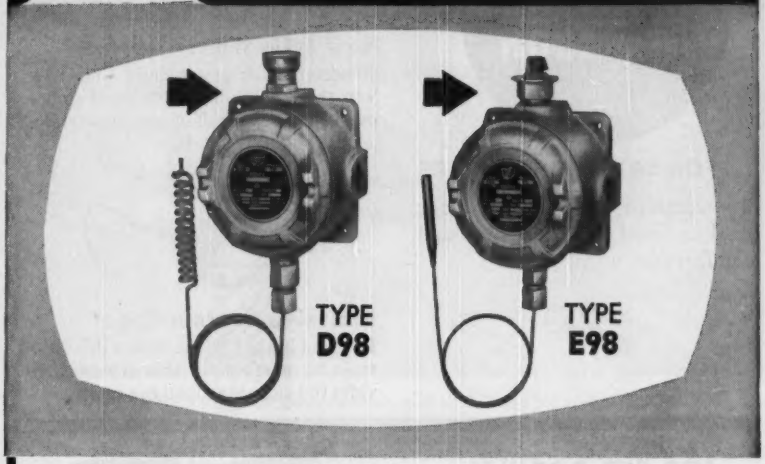
Prebreakers.....Utilizing high torque at relatively low speeds, they will do an efficient crushing & breaking job, replacing in many applications jaw, roll & rotary crushers, hammer mills, shredders, etc. Bulletin 502.
441A Rietz Mfg. Co.

Presses, Filter.....Offer numerous features: lowest cost per sq. ft. of filtering area; produce perfect clarity of filtrate; can be used in decolorizing —deodorizing; etc. Request illustrated Catalog No. 55.
306b *T. Shriver & Co.

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D98 | E98 EXPLOSION PROOF TEMPERATURE CONTROLS



UNITED ELECTRIC has designed the D98 and E98 units to automatically and sensitively control the temperatures of gases, liquids and hot plate applications where explosive vapors and gases are present. Both units feature external, calibrated temperature adjustments. The E98 adjustments are made by a single-turn adjustment knob and pointer, while the D98 has a multiple-turn, micrometer type adjustment.

Temperature Ranges	Type D98 — 300° or 550° F between limits of −150° and +650° F. Type E98 — 100° or 200° F between limits of −150° and +650° F.
Thermal Assemblies	Various shapes and sizes of thermal assemblies available. Completely liquid-filled bellows, bulb and capillary assembly.
Switch Ratings	15 amps. at 115 or 230 volts AC, also 20 amps. or DC switches on specification.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Electrical Connections	Two, ¾" NPT conduit openings in enclosure. Internally-located terminal block.
Size & Weight	9¼" x 5¾" x 3⅞" — weighs approx. 8 lbs. 4 oz.
Enclosure	Class I, group D and Class II, groups E, F and G explosion-proof enclosures; cast iron base, aluminum cover.
ON-OFF Switch Differential	Fixed, uniform throughout specified range.
Mounting	Surface mounted in any position by mounting holes in each corner of base.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. UE will gladly modify or custom-build a unit to meet your specifications. Consult a UE application engineer today.*

Write for Bulletin No. 3-1 for complete D98 data or Bulletin No. 3-5 for complete E98 data.

United Electric Controls
COMPANY
84 SCHOOL STREET, WATERTOWN, MASS

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. . .FOR SAFETY SPECTACLES

that combine the protection your workers need with the style and comfort they want.



New Style WFH

Handsome safety spectacle with new lens shape in frames with demi-amber overlay on upper half of crystal butyrate.



Exclusive Contour-Spec®

Patented hinged bridge makes this spectacle the most comfortable to wear. Provides full closure around eye cavity.

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that provide the utmost in eye protection. The complete range of Willson goggle styles meets every eye protection need.



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This roomy style CC70 goggle is roomy enough to go over almost any style of personal glasses. Rigid top bar makes them easy to put on and take off with one hand.

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for almost any respiratory hazard. The Willson line carries more Bureau of Mines approvals than any other.



Interchangeable Series 800

This is the first truly interchangeable respirator. It requires no additional parts or accessories to make use of 4 different cartridges and 4 different filters or combinations of both.

. . .FOR HARD HATS AND CAPS

In either lightweight Fiberglas, in 5 colors, or fabric reinforced Phenolic Resin, the strongest hat shell made. Choice of four suspensions to suit your individual requirements.





Super-Tough Phenolic

This toughest of all safety hats is reinforced with ten individual die-cut pieces of sturdy duck and molded under pressure to withstand repeated drop-ball tests *without fracture!*

WILLSON PRODUCTS, INC.

Over 300 Safety products carry this famous trademark

106 Thorn Street • Reading, Pennsylvania

LITERATURE . . .

Process Systems . . . . . Allis-Chalmers process system converts fine particles into granular product to meet consumer demand. For complete information, company offers a detailed reference, Bulletin No. 25C6177J.
287 *Allis-Chalmers Mfg. Co.

Pulverizing.....Describes Raymond pulverizing, separating and drying units. Every unit is rugged and dependable . . . designed and built to do your job more simply and at a lower cost. Request Bulletin No. 80.
294 Raymond Div.

Screens, Vibrating.....For high-capacity screening of a broad range of materials—"CA" vibrating screens are your answer. In complete range of sizes to suit all plant capacity requirements. New Book 2554.
40a *Link-Belt Co.

Screens, Vibrating.....For economical separation of light to medium weight materials—choose "UP" vibrating screens. In open, semi-enclosed, or totally-enclosed types. Complete details contained in Book 2377.
40b *Link-Belt Co.

Scrubbers, Gas.....Installations of this equipment successfully handle difficult gas scrubbing problems. Help stop air pollution and recover valuable materials. World-wide usage. Details in Bulletin M-102.
259a *Chemical Construction Corp.

Vessels, High Pressure.....Cole can build you the kind of high-pressure tanks or vessels you require . . . any size, any shape, any metal. For complete product information, request copy of catalog, "Tank Talk."
TL325 *R. D. Cole Mfg. Co.

Wire Cloth.....80 p. catalog describes company's facilities for fabricating wire cloth parts. Includes wire cloth parts for screening, filtering and special uses. Also provides helpful metallurgical information.
420 *Cambridge Wire Cloth Co.

Wire Cloth.....Newark wire cloth is made of all malleable metals such as aluminum, brass, bronze, phosphor bronze, copper, monel, Nichrome, nickel, stainless steel, gold, etc. Request new Catalog E.
409 *Newark Wire Cloth Co.

Pumps, Blowers, Compressors

Blowers.....Wherever bad air slows down production . . . in shipholds, tanks, drums, boilers or other places where men need fresh air . . . a Coppus blower becomes a safety device & a production tool. Request details.
79a *Coppus Engrg. Corp.

Compressors.....York Freon Turbo compressor systems are particularly adapted to high-capacity refrigeration loads. Company makes available a file folder and reprints on their complete line of compressors.
33-4 *York Corp.

Compressors, Centrifugal.....Offers a complete line of centrifugals for gas compression and refrigeration—up to 10,000 horsepower in a single unit. Details in booklet, "Centrifugal Compressors for Industry."
258 *Carrier Corp.

Compressors, Oil-Free.....The WGO-9 offers space-saving design, excellent service, economical operation, etc. Company builds regular & oil-free compressors to meet capacity & pressure needs. Bulletin A-44.
7 *Joy Mfg. Co.

Fans.....Profusely illustrated, 72 p. describes the new Series 106 Industrial Fans which provide complete full-range coverage of industrial air and material handling requirements. Request your copy of Bulletin 5306.
443A American Blower Corp.

* From advertisement, this issue.

Pumps.....Practical Guide to Pump Selection—illustrations & descriptions with capacities & adaptability of facts to help avoid costly misapplication. Bulletin No. S-146.
L417 *Taber Pump Co.

Pumps.....For transfer, metering, spray drying, a Gaulin Triplex pump is a rugged, heavy-duty machine built to minimize operating, etc. Its horizontal design makes every part accessible. Bulletin P-55.
62 *Manton-Gaulin Mfg. Co.

Pumps.....Pump liquids—gases—slurries . . . without corrosion or contamination. Wavelike motion of steel fingers forces material through tubing. Makes available a descriptive Catalog containing full details.
BR448 *Sigmamotor, Inc.

Pumps.....For most efficient, carefree service in moving liquids, you can depend on Frederick SSV pumps. Constructed of metals to meet your requirements. Offers Bulletin which describes these pumps, No. 107.
L306 *Frederick Iron & Steel

Pumps, Acid.....On most difficult pumping jobs . . . dependable highly efficient pumps deliver continuous, trouble-free performance on 'round-the-clock schedules wherever they are installed. Full details.
55 *A. R. Willfley & Sons.

Pumps, Centrifugal.....New paper stock & industrial liquids pump features a diverging type impeller which enables it to handle liquids containing high-concentrations of solids, air & gases. Bulletin No. 7325.
225 Ingersoll-Rand Co.

Pumps, Centrifugal Chemical.....Worthington offers you the widest standard corrosion-resistant pump line as Karbate impervious graphite supplements Worthite. Request Bulletins W-350-B14A and W-350-B18.
82-3 *Worthington Corp.

Pumps, Centrifugal & Displacement..... Illustrated 4 p. folder describes a complete line of small rotary displacement & centrifugal pumps designed to meet specific demands of the chemical & allied process industries.
443B Eco Engrg. Co.

Pumps, Chemical.....Furnishes a complete line of Buffalo pumps, ready to handle corrosive or abrasive liquids at least maintenance cost. For full product information, request illustrated Bulletins 976 and 982.
419d *Buffalo Pumps.

Pumps, Chemical Oil-Lubricated..... Recommended for pumping liquors, corrosive materials and solutions in the most used ratings to 3500 gpm, heads to 400 feet for liquids to 550 F. Request Bulletin 52B7638.
46 *Allis-Chalmers Mfg. Co.

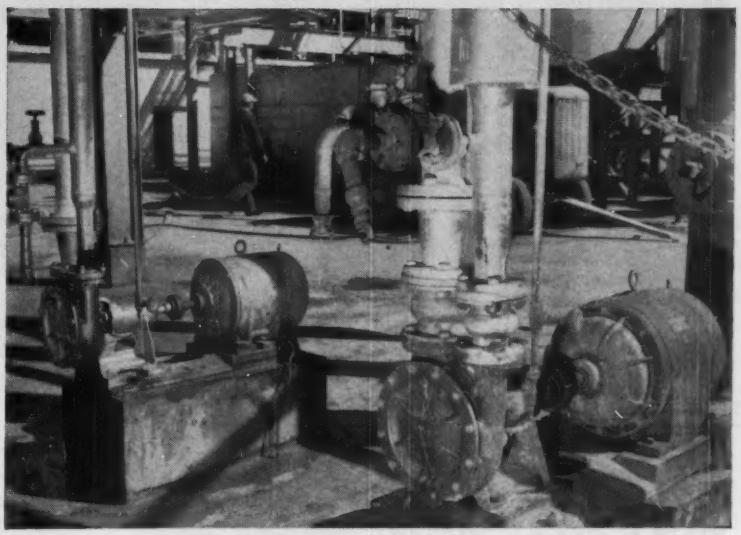
Pumps, Direct Flow.....The Direct Flow principle, an Aldrich design innovation, is a major forward step toward the solution of tough pumping problems of all kinds. Request descriptive Data Sheets.
R431 *Aldrich Pump Co.

Pumps, Double Suction.....Hydraulically balanced, highly efficient and durable. In sizes to deliver from 10 to 14,000 gpm for circulating, air conditioning, other plant services. Details in Bulletin No. 995-Q.
419c *Buffalo Pumps

* From advertisement, this issue.

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Simply circle the code numbers desired on the handy pre-paid postcard, and mail it to us. Replies will reach you direct from the companies manufacturing the products.



These Fig. 3705 Goulds stainless steel pumps move hot sulphate (50° C.) and potassium chloride (40° C.) solutions with as high as 30% solids, at the Carlsbad, N. M. plant of the International Minerals and Chemical Corporation. The Fig. 3715 pump discussed below is an improved design of this pump.

No heartburn in these pumps as they move *hot, corrosive* and *abrasive* liquids

The sulphate and potassium chloride solutions handled at this plant would soon eat the heart out of an ordinary pump.

That's why International Minerals and Chemical Corporation uses Goulds *chemical* pumps.

They are available in Gould-A-Loy 20 stainless steels, all iron, all bronze, iron with stainless steel or bronze trim, and bronze with stainless steel trim. You can fit the pump to the job, obtain many long years of trouble free service.

Here are just a few of the other extra features you get:

1. You can move liquids at temperatures up to 350° F., because the pump has quenchable cowl-type glands and cooling chamber in the support head.

2. Stuffing box on suction side of impeller gets suction pressure only, holds leakage at a minimum.

3. You can change easily from conventional stuffing box to single or double mechanical seal.

4. You can inspect and clean the pump without disturbing piping connections.

These Goulds Fig. 3715 chemical pumps are available in nine sizes with capacities up to 720 GPM and heads, depending on capacity, up to 200 ft.

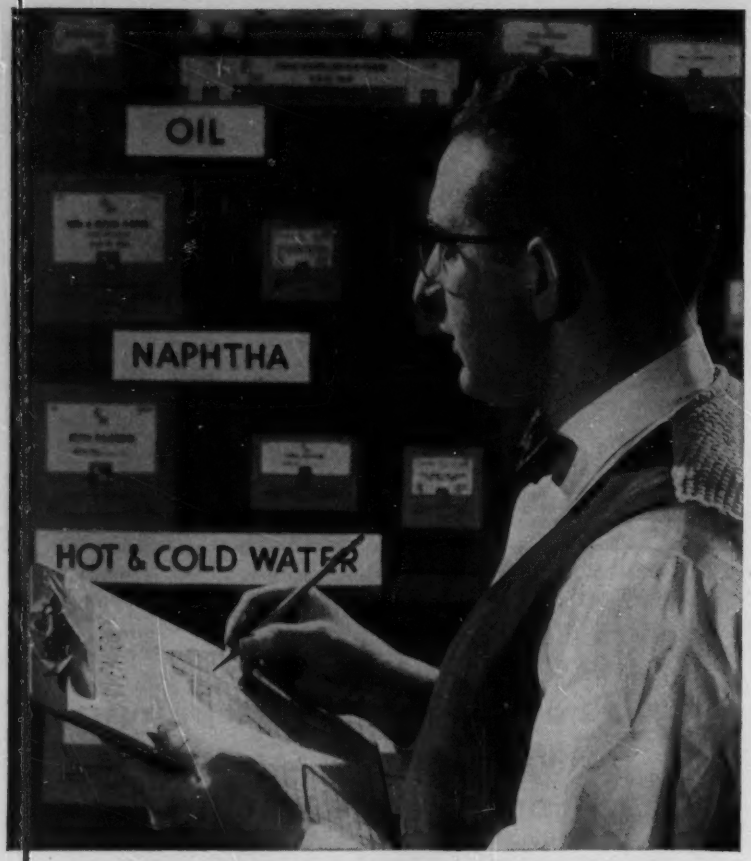


See all the special features of the Fig. 3715 pump in your own office. We've made an aluminum model which you can take apart on your desk. Just ask your Goulds representative to show it to you. Or, write to our main office and we'll make the arrangements.

MEMBER HYDRAULIC INSTITUTE

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YOU CAN GREATLY REDUCE YOUR PUMP PACKING INVENTORY WITH R/M "VERSI-PAK"®

R/M "versi-pak" is so scientifically engineered that it can be used with outstanding effectiveness on many kinds of pumps. Though primarily designed for solvent and oil service up to 350°F. and 600 psi, it does a superior job on water solutions, weak acids and caustics. Its use eliminates the necessity of stocking many special packings.

R/M "versi-pak" is a dense, relatively inert packing with high compressibility that provides positive sealing at high pressures while maintaining relatively low pressure on the packing gland. It allows glands to be taken up to compensate for wear, and its low coefficient of friction and retention of original lubrication reduce heat build-up during operation.

There are R/M "versi-pak" packings for every service—air, water, oil, low-pressure steam, and food products. For complete information, write for this booklet.



R/M MAKES A COMPLETE LINE OF MECHANICAL PACKINGS—including Vee-Flex, Vee-Square, Universal Plastic, and "versi-pak"®; GASKET MATERIALS. "TEFLON"* PRODUCTS. SEE YOUR R/M DISTRIBUTOR.

*DuPont trademark

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LITERATURE . . .

Pumps, High Vacuum.....Describes Kinney high vacuum pumps . . . for every industrial and scientific application. Product line is the largest of any in the world. For complete information, request Catalogue 425.
105 *Kinney Mfg. Div.

Pumps, Hydraulic Pressure Exchange..... Describes Manton-Gaulin line of hydraulic pressure exchange pumps . . . designed to handle corrosive and erosive slurries & solutions at high temperatures. Bulletin HPX-55.
44A Manton-Gaulin Mfg. Co.

Pumps, Paper Stock.....For handling high consistency liquids—save money and trouble with non-clogging paper stock pumps. Available in alloys or rubber-lined for corrosive and abrasive liquids. Bulletin No. 953.
419a *Buffalo Pumps.

Pumps, Piston-Diaphragm.....For controlled-volume pumping of fluids. Flow-charts, typical applications, description & specifications and models of various capacities & constructions in Bulletin No. 500.
93 *Lapp Insulator Co.

Pumps, Positive Displacement.....Give you smooth, even discharge like you will get with all Viking Pumps—Viking pumps plus good piping means good pumping. For more complete information, see Bulletin 56Sc.
BL327 *Viking Pump Co.

Pumps, Positive Displacement.....Designed with the spring-loaded, John Crane rotary seal, they are recommended for non-abrasive products having corrosive properties. Request complete product details.
263 *Waukesha Foundry Co.

Pumps, Process.....Fully illustrated, 20 p. describes line of vertically split, single-stage & two-stage type process pumps. Includes design features, dimension tables, cross sectional views, etc. Bulletin Form 7094-B.
444B Ingersoll-Rand Co.

Pumps, Process.....De Laval CPO-process pumps handle numerous liquids; salt brine; sea water; caustic solution; soap solutions; etc. Capacities to 2000 gpm—heads to 200 ft. Details in Bulletin No. 1125-B.
267 *De Laval Steam Turbine Co.

Pumps, Process.....Type Z4 APCO process pump is ideal for the handling of liquefied petroleum gases, refrigerants & other light non-viscous liquids. Latest design features. Details available on request.
TL321 *Aurora Pump Div.

Pumps, Proportioning.....Describes new Microflex Chemical Proportioning Pump . . . with a pressure range up to 60,000 p.s.i. Covers the outstanding features and advantages. Request illustrated Bulletin 4064.
444C American Instrument Co.

Pumps, Sump.....Three advantages are featured in the "Buffalo" sump pump: easy installation; always in prime (since there is no suction lift); & simplified maintenance. For details, request Bulletin No. 963-F.
419b *Buffalo Pumps.

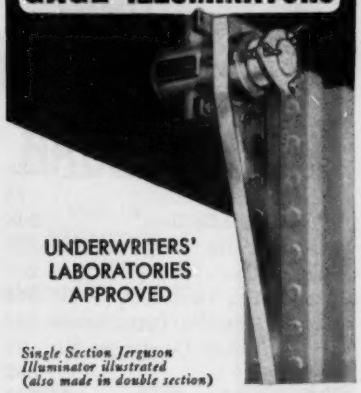
Pumps, Vacuum.....Beach-Russ vacuum pumps give: fast "pump-down"; high efficiencies; quiet, vibrationless operation; long service life; etc. For complete information on line, request General Bulletin 89.
R425 *Beach-Russ Co.

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Simply circle the code numbers desired on the handy pre-paid postcard, and mail it to us. Replies will reach you direct from the companies manufacturing the product.

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You Get Even, No Glare
LOW COST LIGHTING
for Gages, Rotameters, etc.
with JERGUSON
Explosion-Proof
GAGE ILLUMINATORS



UNDERWRITERS' LABORATORIES APPROVED

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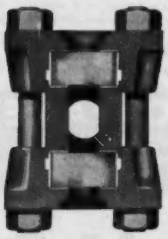
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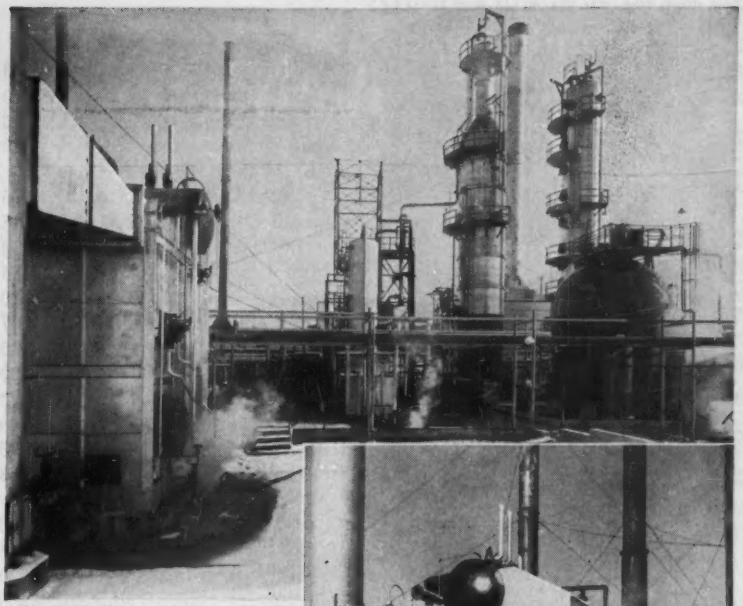
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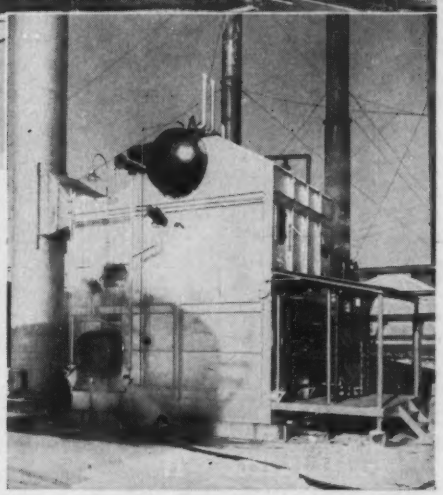


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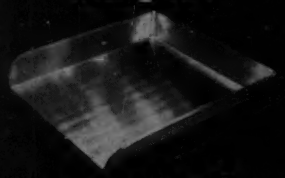
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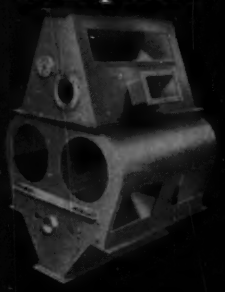
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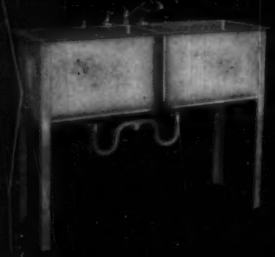
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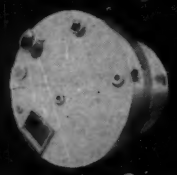
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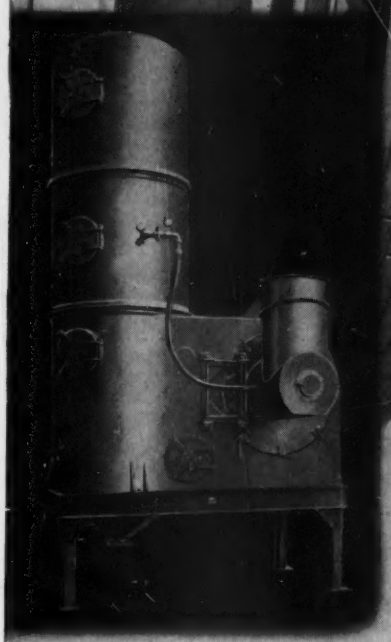
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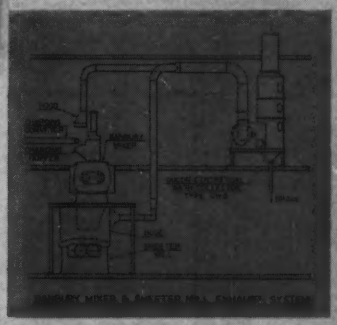
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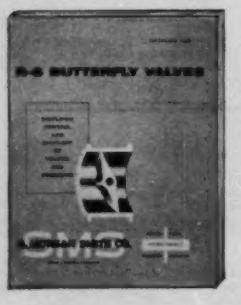
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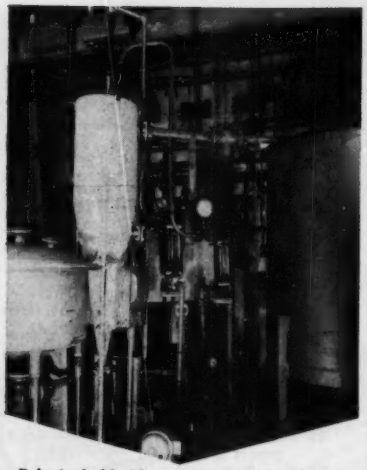
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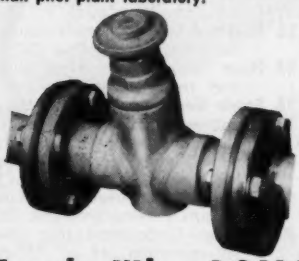
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Polyvinyl chloride processing tank (above) and flanged pipe and valves (below) in small pilot plant laboratory.



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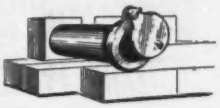
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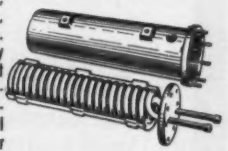
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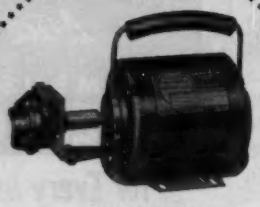


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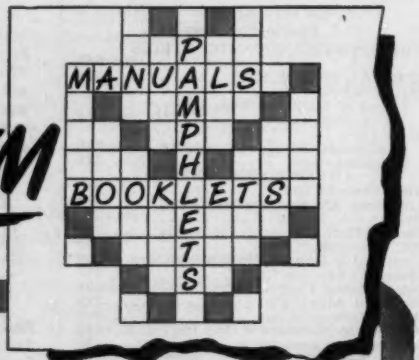
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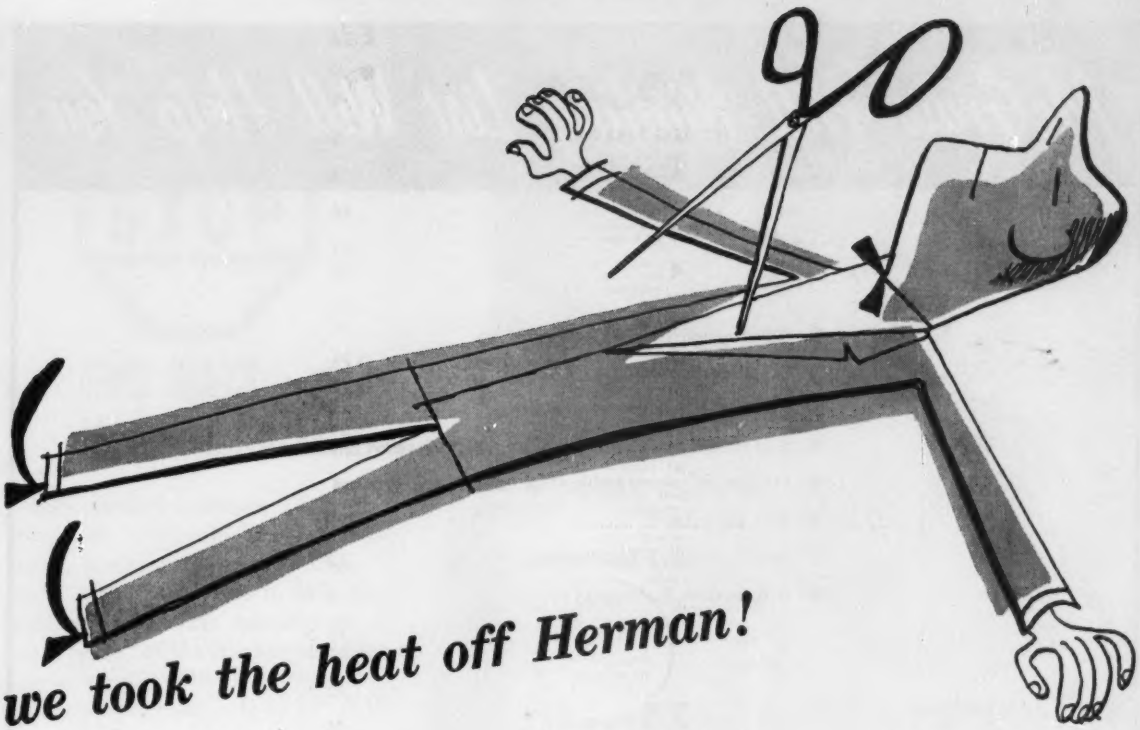
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Seems his wife was pretty proud of her sewing. So was Herman – always talking it up at the plant about how much dough she saved on clothes. Only trouble was, she just had one pair of scissors, and Herman was forever borrowing 'em to cut out reading material from CHEMICAL ENGINEERING.

The day the *Inventory Issue* arrived though, he knew his snippers-snitchin' days were over. Saw right away how it wrapped up 12-months' key developments and eliminated his clip-and-file system in one fell swoop. New technologies, new plants, new chemicals and equipment, that wonderfully convenient Reader Service . . . *the works!* He was in ecstasy.

Couldn't understand when he told his wife about it though. She just up and fainted. Later, he keeled over himself when he found out she'd planned a scissorcide the next time he grabbed her shears.

But all's well now. A little vacation did the trick for mama. Today there's no happier CPI couple east of the Pecos. No snips around the house though – the little lady's clothes are all store-bought. And the only bragging Herman does at the plant is about *how much time he saves* . . . with the *Annual Inventory Issue of* CHEMICAL ENGINEERING.

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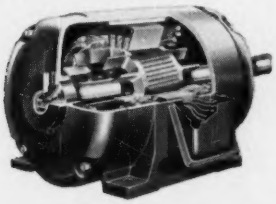
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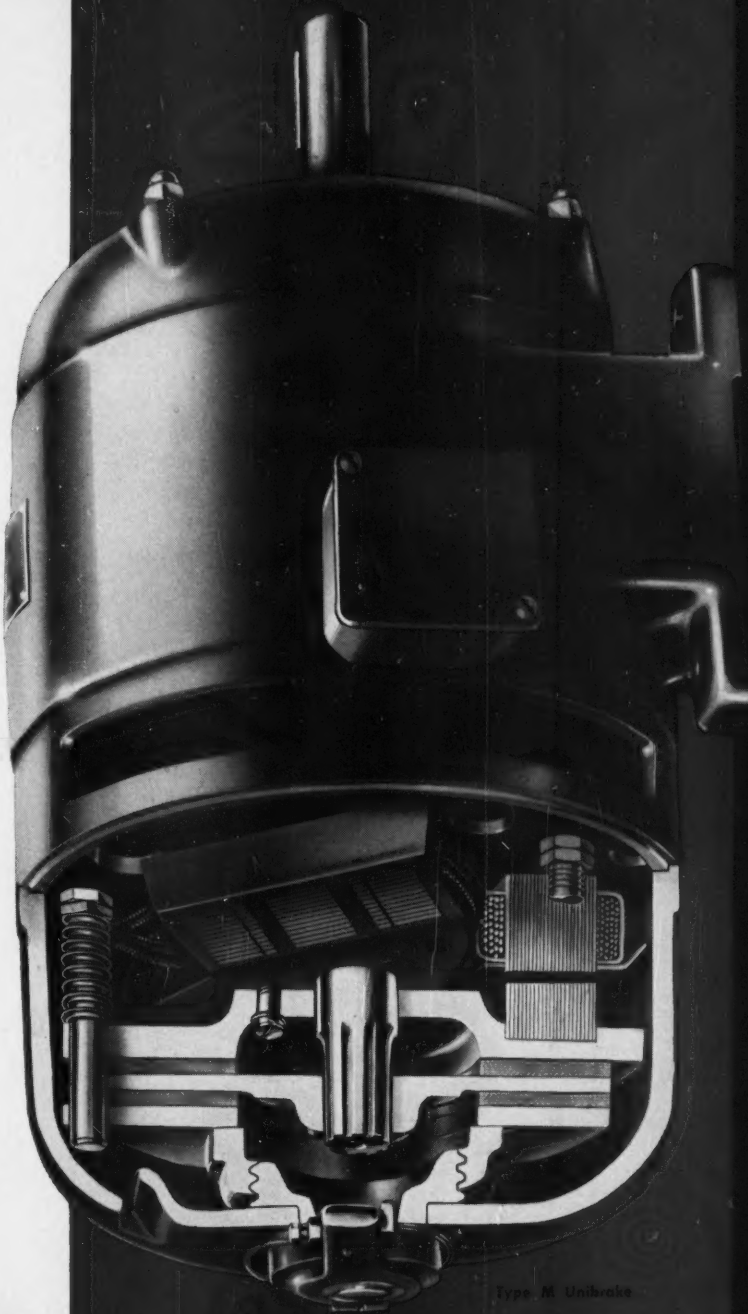
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Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Temperature: up to 550° F.
Contamination: 0



Contamination from walls of kettle was eliminated by using this 3500-gal. glassed steel vessel.

How this reactor solves 6 problems for Argus Chemical

Making heat and light stabilizers for PVC is a touchy job. You can't risk contamination of your product, and you have to control temperatures within ±1° F., if you want to produce the best quality.

And your operating temperatures range up to 550° F. This combination of conditions posed quite a problem for the men assigned to select equipment at Argus Chemical. They needed a material that was: 1) easy to clean, 2) nonadherent, 3) nonmetallic, 4) capable of accurate heat transfer, 5) corrosion resisting and 6) immune to high temperatures.

Argus solved their problem with the 3500-gallon Pfaudler glassed steel reactor shown here. Using the acid-alkali resisting properties of Pfaudler glass, backed by the structural strength of steel, they added a forced recirculation heating system using Aroclor 1248, Monsanto's fire-resistant heat transfer oil. This gave the fine temperature control they insisted upon. Because practically nothing sticks to glass, they had their freedom from contamination.

You can now obtain these Pfaudler glassed steel reactors in low-cost standard designs, up to 4,000 gallons. Besides the advantages mentioned above, they incorporate many convenience features, such as extra-big manhole, a total of nine top head openings, exclusive Pfaudler agitation, offset bottom outlet and others.

NEW TAKE-IT-APART AGITATOR IS EASIER TO USE AT BOTH ENDS

Increases reactor utility, decreases maintenance cost

Now glassed steel is easier than ever to use! Besides its exceptional corrosion resistance and reasonable cost, it is fast becoming the most flexible equipment on the market.

Latest development is a separable blade agitator, which you assemble *inside* the reaction kettle.

This permits you to switch impellers in a jiffy, without disturbing the drive or seal. And it enables us to use a smaller agitator opening, providing more working space at the top head for additional openings, if desired.

Needs only 1 tool

All you need to assemble the impeller is a strap wrench. Assemble the two sections of the blades, then anchor them with the glassed hex nut. All metal parts of the agitator are glassed, and all gaskets are Teflon shielded.

Besides lowering maintenance and changeover time, this agitator cuts stock costs, because you don't have to store the whole fixed agitator-impeller assembly. Just stock an extra impeller, at much lower cost.

Stuffing box or seal

At the top end, another new development increases the versatility of this agitator. It's designed to work with either stuffing box or rotary seal, permitting changeover in a matter of minutes. This is important when your process changes and a different type of seal is needed quickly.

If you'd like to discuss the working convenience of this new development, get in touch with your Pfaudler representative.



* Patents Pending



IMPELLER has separable blades held together by glassed hex nut.

Reprints available:

Study reveals influence of carbon in glassed steel

The role of carbon in the enamelling of steel is important to you, if you process corrosive chemicals, since glassed steel is often the only equipment suited for such service.

After a thorough probe into the subject, three authorities have pooled their knowledge and incorporated their findings in a paper which appeared in the Journal of the American Ceramic Society.

Its title: "Some Influences of Carbon in Enamelling of Steel." The authors: Gordon P. K. Chu (of Pfaudler research), J. K. Magor (R.P.I.) and H. M. Davis (Penn State). Reprints available on request.

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